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THE ANATOMY OF THE HEAD

THOMAS DWIGHT M.D.

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THE ANATOMY OF THE HEAD.

THE

ANATOMY OF THE HEAD

WITH SIX LITHOGRAPHIC PLATES REPRESENTING
FROZEN SECTIONS OF THE HEAD

BY

THOMAS DWIGHT, M. D.

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PREFACE.

THE object of this book is to assist the student to gain an idea of the head as a whole, as it exists during life. It has appeared to me that this which is the most valuable, indeed the only true, knowledge of anatomy, is somewhat overlooked in the methods of instruction in vogue in America, and I believe also in England. With us the attention is directed chiefly to descriptive anatomy, and the relations of parts to one another are neglected, except such as are of evident surgical importance. Knowledge of anatomy may be compared to that of a city. Many can enumerate the streets crossing the great thoroughfares, can even draw pretty accurate diagrams of the main streets and squares, but be absolutely ignorant of the direction of distant places from one another and consequently of the short cuts between them and what is to be encountered on the way. One who knows all this may be said to know the city, and he who can tell what a rod thrust through any part of the body will strike knows anatomy in its most practical aspect. Histology holds no place in this work, nor have I thought it advisable to discuss many of the smaller details, but I have tried to impress on the student the general plan. To obtain this knowledge the study of frozen sections is of great value. It never can take the place of dissection; but, on the other hand, these sections give views that can be obtained in no other way, and which, due allowance being made for *post-mortem* changes, must necessarily be true. The plates are bound in a manner to be easily consulted, and the reader is urged to consult them frequently, even when his attention is not directly called to them by references in the text. The sections which they represent were made by me from one head, that of an elderly man, and belong to the cabinet of the Medical School of Maine. The drawings were made under my immediate supervision and are very accurate, as I endeavored to resist the temptation to improve nature. I must admit that an exception was made in Plate I. in favor of the left eye, which was much distorted as the head was not very fresh. For the same reason some slight additions were made to the brain, but otherwise the plates are as exact as they well can be. Some conventionality in the treatment, is of course, unavoidable.

THE AUTHOR.

70 Beacon Street, Boston,
August, 1876.

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INTRODUCTION.

In this work the head will be held to include all above the hyoid bone. Usually the parts under the chin and behind the angle of the jaw are classed with the neck, and the posterior portion with the back. This arrangement is convenient for description, owing to the continuity of some of the structures in these regions with those below; but in order to obtain an idea of the head as a whole, I prefer to add to it the first two vertebræ rather than to take from it. The transverse sections represented in the plates show excellently the plan of the head. Behind, it consists of the skull, containing the posterior lobes of the brain and the cerebellum, projecting backwards from the spine and overhanging a solid mass of muscle. Farther forward the cavity runs down into that of the spinal canal and is filled by the medulla connecting the brain and cord. On front of this comes the column of the vertebræ, and above that we see the temporal bones projecting boldly into the cranial cavity and shutting off the posterior fossa in which the cerebellum is imprisoned. The skull becomes more shallow on front of this, and the cavity of the pharynx reaches to its base, at the sides of which are the outer ear and the joint of the jaw. The parotid gland, the cervical vessels, and the thick muscles of mastication fill up the space on both sides of the pharynx, which opens below into the œsophagus and trachea. The base of the skull splits at the middle into two layers, which inclose the sphenoidal sinus. The pharynx is continued anteriorly into the nasal cavities, and into the mouth when the tongue is depressed. More anteriorly at the plane of the anterior fossa of the skull, we find the latter small, and the greater part of the section occupied by the face, which is a mere light framework of delicate plates of bone, showing little strength, except in the lower jaw and around the teeth of the upper one. The nasal cavities are in the middle over the roof of the mouth, and on each side of them are the antra of the upper jaw, and over these the orbits. In the angle between the orbits and the top of the nasal cavities are the ethmoidal cells. Such is the outline; we proceed to the details.

THE ANATOMY OF THE HEAD.

CHAPTER I.

THE SKULL.

General shape of skull.

THE skull may be roughly described as an egg-shaped case with a flattened under surface, the fore part of which gives attachment to the face. The sides, the top, and the back of the case are formed by flat bones, consisting for the most part of two layers, an outer and an inner table, with spongy tissue known as diploë between them; but where the walls are very thin there is but a single layer. The vault of the skull presents but two minute and inconstant openings, the parietal foramina, for the passage of small veins; but the base contains many openings and is of quite a different structure: in parts of it the bones are hollowed into mere shells, forming chambers communicating with the pharynx and lined with mucous membrane; in parts the bones contain cancellated tissue, such as is found elsewhere, and again parts are made of solid bone. The base is decidedly the weakest part.

Upper view.

Viewed from above the skull has usually an oval outline, the greatest breadth being behind the middle and between the two parietal eminences, which are much less prominent in the adult than in the child. They may be said to decrease steadily from birth to adult age. The same is true, but in a greater degree, of the two frontal eminences, which are very marked in the infant but often hardly perceptible in the full grown skull. The serrated sagittal suture runs in the middle between the parietal bones to a point somewhat in front of the summit, where it strikes the coronal suture, which forms a curved line with an anterior concavity bounding the frontal. This bone is developed from two chief centres, corresponding to the frontal eminences; and at birth there are two distinct frontal bones separated by the frontal suture. At the point where this suture and the sagittal meet the coronal one, the bones are rounded at birth, and thus there is left a diamond-shaped space known as the anterior fontanelle, that closes in the course of the first year. The frontal suture is sometimes persistent, but it almost never is directly continuous with the sagittal. The lambdoidal suture bounding the occipital bone is barely seen from above. The shape of the head has been thought to depend on the relative time of closure of these sutures. According to this theory, uncommon length is due to premature closure of the sagittal, and uncommon shortness and breadth to that of the frontal and lambdoidal. The correctness of this view has been doubted; but whether or not it be more than a coincidence, it is certain that the appearance of the sutures in many skulls tends to confirm it. The fact that a persistent frontal suture is very rarely found except in broad skulls,[1] is in its favor. The minute parietal foramina, when present, are found in the upper posterior angles of the parietals; they are very rarely greatly enlarged. The two sides of the head are very seldom, one might almost say never, symmetrical. Usually the front of one side and the back of the other are more prominent than the corresponding parts. An excellent demonstration of the constancy of this asymmetry, and of the extent it may reach, is to be found in a hatter's collection of outlines of the head.

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[1] Simon, Virchow's *Archiv*, vol. lxxxv.

Posterior view.

The skull seen from behind suggests a pentagon, and this shape may be very marked. One side is formed by the base, two others by the sides of the skull below the parietal eminences, and the remaining two by the borders from these points to the vertex. The squamous portion of the occipital bone appears as a triangle bounded by the wavy and irregular lambdoidal suture. This frequently contains one or many separate bones — Wormian bones; and it is not very rare to find one large one in the place of the upper part of the occipital. Low down, near the junction of this surface with the base, is the external occipital protuberance, ranging from a slight swelling to a very prominent knob. From each side of it the superior curved line runs toward the mastoid process and marks the height to which the muscles of the back of the neck rise on to the skull.

Front view.

The front view shows the skull coming down to the roof of the orbits and the root of the nose. Just above the latter there is a short suture, formed by many fine transverse serrations, which is the remains of the lower end of the obliterated frontal suture. Above and to the sides of this are the superciliary eminences caused by the development of the frontal sinuses. The upper boundaries of the orbit slope downward towards the outer angular processes on which they end; but this is not the case with the roof of the orbit. The processes just mentioned project outward from the side of the head and join the malar bones. According to v. Jhering,[1] they are developed from separate centres. Near the inner end of the upper border of the orbit is found the supra-orbital notch, or foramen, as the case may be.

A clearer idea of the side view of the skull may be obtained by removing the lower jaw and sawing off the

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[1] Reichert and Du Bois Reymond's *Archiv*, 1872.

Side view of skull proper.

zygoma, the pterygoid, and the styloid processes, as certain parts of some cranial bones belong practically to the face. If the head be in the normal position, the lowest point will be the mastoid process. Just on front of the base of this process is the external auditory meatus, and above both of these a ridge which runs into the zygoma. The front of the auditory process which surrounds the meatus, and curves in to form part of its roof, is the border of the tympanic plate. This extends downward into a pointed shield over the origin of the styloid process, known as the vaginal process, and upwards to the articular layers of the joint of the jaw, from which it is separated by the Glaserian fissure. The upper part of the side of the head is formed by the parietal and frontal, the lower by the temporal and a part of the greater wing of the sphenoid. The coronal suture normally strikes the upper part of the sphenoid, thus separating the temporal and the frontal. The curved suture bounding the squamous bone, when it reaches its lower portion, is continued nearly straight backward to the lambdoidal. The conventional regions on the side of the skull are of much importance. It is customary to call that part of the cavity between the skull and the zygoma that is above that process, the temporal fossa, and that below it the zygomatic. The temporal fossa has been described as bounded above by the temporal ridge or line which arises from the external angular process of the frontal, and arches back across the parietal, but this line was found to present most extraordinary variations. If it were true that it shows the origin of the temporal muscle, this muscle in some skulls of no especial development would have done credit to a gorilla. The fact is, as Hyrtl[1] has shown, that there are two curved lines, both

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[1] *Denkschriften der Academie der Wissenchaften zu Wien*, Bd. XXXIII.

Two curved lines in parieto-temporal region.

starting from the point mentioned, but diverging as they travel backward; the upper one runs over the parietal eminence to the lambdoidal suture, which the lower never touches; and the latter, crossing the lower part of the parietal, runs into the line already spoken of, which forms part of the root of the zygoma. It is rare to find the whole of both lines well marked, and either one or both may be wanting; but usually parts of both may be made out. The lower one marks the origin of the temporal muscle, and the upper, according to Hyrtl, merely separates the lateral from the superior aspect of the skull. V. Jhering[1] believes that the upper one serves for the attachment of the temporal fascia, — a point we will consider later.

Inferior view of skull.

The inferior aspect of the base of the skull is in part quite hidden by the face. We will begin with the posterior portion. From the back of the foramen magnum a line runs to the occipital protuberance, and is crossed at about the middle of its course by the inferior curved line. Two spaces are thus marked off on each side, one between the two curved lines and the other between the inferior one and the foramen magnum. The former of these spaces is occupied by the complexus; the latter, by the short muscles from the first two vertebræ. On the sides of the anterior half of the foramen magnum are the condyles, and above these the anterior condyloid foramina, for the passage of the hypoglossal nerves, and behind them the inconstant posterior condyloid foramina for veins. The mastoid processes, the centres of which are in a line somewhat posterior to one through the middle of the condyles, present a deep groove on the inner side for the origin of the digastric muscle, and a smaller one is seen internal to the latter for the occipital artery. Just on front of the digastric groove is the stylo-mastoid foramen, which gives exit to the facial nerve. On front of the foramen magnum, the basilar process runs forward, forming a central beam of support. Its under surface is rough, and half an inch in front of the foramen magnum there is a tubercle for the attachment of the top of the pharynx. On each side of the basilar process there is a fissure of some size between it and the petrous portion, and at the apex of the latter is the middle lacerated foramen. During life, both the fissure and foramen are filled with cartilage, and, it may be, with small ossifications. From the base of the pterygoid process there is a groove between the great wing of the sphenoid and the petrous portion for the Eustachian tube, and behind that the free edge of the tympanic plate. On front of the groove are the foramen ovale and the foramen spinosum, for the third division of the fifth pair of nerves and the middle meningeal artery respectively. The under side of the petrous portion of the temporal is very important on account of its relation to the openings for the carotid artery, and for the jugular vein and the ninth, tenth, and eleventh pairs of cranial nerves. Internal to the tympanic plate which guards its entrance is the round orifice of the carotid canal. Inside the bone this changes its course so that the vessel emerges at a right angle to the direction in which it enters. Behind the carotid foramen is a depression known as the jugular fossa, which is usually not a part of the jugular foramen, but lies external to it. It is usually described as a smooth, thimble-shaped cavity, but there are many cases in which this description is quite incorrect, and must be very confusing to the student. There are two very different forms, and, of course, numberless intermediate ones. The most com-

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[1] Reichert and Du Bois Reymond's *Archiv*, 1875.

Formation and variations of jugular foramen and fossa.

mon plan is the following, represented in Fig. 1. Outside of the condyle there is a large irregular opening, which transmits the vein and the nerves. Its posterior border is formed by the occipital, which is smooth for the vein, but which, towards the inner and anterior end of the foramen presents a slight ridge, which cuts off a small anterior part for the nerves. External and anterior to the smooth part is the hollow, thimble-shaped cavity (*a*) in the temporal, the upper border of which is much deeper than the surface of the skull, and forms the edge of the foramen at the inner aspect, so that the cavity receives the vein after its exit. The front edge (*c*) of this is prolonged into a process, — the "processus infra jugularis" of Henle (*d*), — and from it to the ridge of the occipital, already mentioned, there runs a ligament separating the smaller anterior foramen for the nerves. Instead of this ligament, there is sometimes a bridge of bone. The most opposite form (Fig. 2) is associated with a small foramen, and it may be mentioned that those of the two sides are rarely equal. In this form, the notch in the occipital bone is small, and instead of this thimble-shaped cavity in the temporal, there is merely a small vertical wall of bone (*a*), forming the outer limit of the foramen, and presenting a prominent infra-jugular process (*d*). The foramen, in fact, is simply a slit.

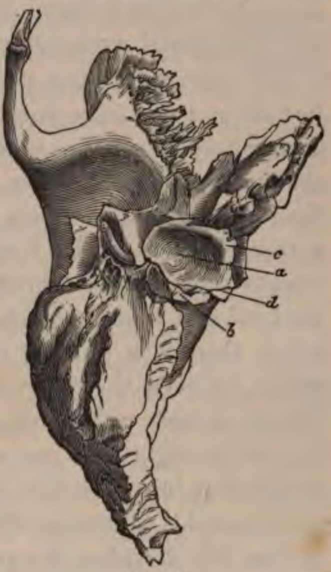

Fig. 1.

Difference between jugular foramina of the two sides.

"The difference between the foramina of the two sides does not result solely from the quasi-occidental asymmetry of corresponding parts, but, as a rule, from peculiar arrangements of the venous channels. The difference of the relations is well shown by vertical sections. Fig. 3 represents such a section through the head of a young subject, in which there is a striking disparity between the foramina. The cut is made rather obliquely; on the right it is one sixteenth of an inch in front of the stylo-mastoid foramen, while on the left it strikes the posterior wall of the canal (F) leading to it, yet such is the asymmetry of the skull that, while on the right the

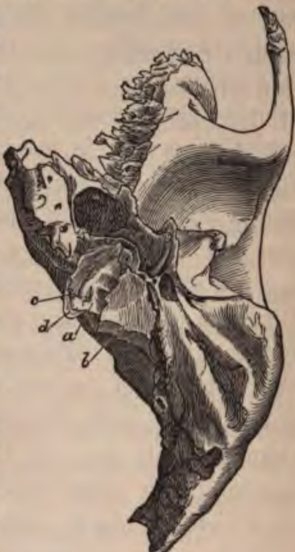

Fig. 2.

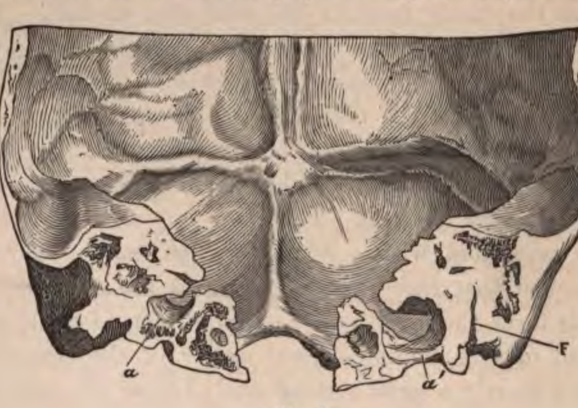

Fig. 3.

jugular foramen (a) is fully opened, the section on the left is just behind its orifice, and shows the lateral sinus (a') turning over the jugular eminence. To ascertain whether there is any fixed relation between the size of the opening, the shape of the fossa, and the size of the anterior and posterior condyloid foramina, the writer has examined very carefully the skulls in the Museum of the Boston Society of Natural History, and those in the private collection of his friend, Dr. J. Collins Warren. After the rejection of some more or less mutilated specimens, there remained 159, ancient and modern, representing races from nearly all quarters of the globe. The first step was to study the variations in size of the jugular foramina of the two sides of the same skull. (The posterior or venous portion is, as already intimated, the important part, as influencing the size of the opening.) This foramen was larger on the right in 104 cases, on the left in 38, and those of the two sides were equal in 30. In the same 142 skulls, the posterior condyloid foramen was larger on the same side as the larger jugular foramen in 53, on the other side in 37, and they were equal or absent in 52. In the same series, the anterior condyloid foramen was larger on the same side as the jugular in 16 skulls, on the other in 11, and the two were equal in 115. It should be mentioned that the differences between the anterior condyloids were, with one or two exceptions, extremely slight. There does not appear to be any definite relation between their size and that of the posterior condyloids. The above figures are obtained by adding together the results of the examination of the two main classes: those in which the jugular foramen was larger on the right and left respectively. In the 17 skulls in which they were even, the neighboring parts, though not quite alike, presented nothing worthy of de-

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24/36 9/36 4/36

scription. To sum up roughly, we may say that, of 159 skulls, about two thirds had the jugular foramen larger on the right side, about one fourth on the left, and about one ninth had the two equal; further, that about two thirds of those having the foramina unequal, had the larger fossa on the same side as the larger foramen, while less than one seventh had it on the opposite side; and, lastly, that the posterior (and in a less degree the anterior) condyloid foramen was much more frequently larger on the same side as the jugular foramen than on the other."[1]

Professor Rüdinger[2] has published some observations on this point from a work which has not yet appeared, in reply to Professor Moos of Heidelberg, who has been inclined to trace some connection between dilatation of the bulb of the jugular vein and psychical affections. Out of one hundred human skulls Rüdinger finds that in sixty-nine the right jugular foramen is the larger, the left one in twenty-seven, and that the two are equal in four. Just external to the front part of this foramen is the small triangular opening of a canal, the aqueductus cochleæ, for Jacobson's tympanic branch of the glasso-pharyngeal nerve.

Interior of skull.

As we are more interested in the appearance which the interior of the skull presents during life than that of the skeleton, we need discuss only some of the more important parts of the latter. Starting at the foramen magnum we have on the front of it the basilar process, the continuation of which forms the back of a small hollow called the sella turcica, in which the pituitary body hangs. From the side of the skull opposite a point above the base of the mastoid process, there runs forward on each side a very prominent ridge, formed by the superior angle of the petrous portion of the temporal bone which separates the posterior from the middle fossa. At the back of the roof of the orbits, and overhanging the middle fossa, is the posterior border of the lesser wing of the sphenoid which ends as a sharp process, the anterior clinoid, over the side of the sella turcica, and separates the middle fossa from the anterior. Thus there are three fossæ, the anterior of which is the highest, its floor being formed by the roof of the orbits and the intermediate cribriform plate of the ethmoid. In its centre is the upward projection of the vertical plate of the ethmoid into the crista galli. The middle fossa is broad externally, and narrow in the middle of the skull, where the two sides communicate at the sella turcica. The posterior fossa for the cerebellum, medulla, and pons, is the largest and deepest. The upper border of this one is marked behind by the internal occipital protuberance and the lateral sinuses till the latter turn down under the edge of the petrous portion.

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[1] This extract is from a paper by the author on the jugular foramen that appeared in the *American Journal of the Medical Sciences*, for October, 1873. The three figures that accompanied it have been kindly furnished for this work by the publisher, Mr. Lea.

[2] *Monatschrift für Ohrenheilkünde*, 1875, No. 1.

The base is the weakest part. The posterior part of the basilar process is tolerably strong, being composed of pretty firm spongy substance. The sella turcica, as well as all the body of the sphenoid, is simply a shell inclosing the sphenoidal sinuses. The orbital plates, though thickened by elevations bounding the digital impressions, are very thin, and the sieve-like plate of the ethmoid between them is extremely delicate. The petrous portion gives a false idea of its strength, for in spite of its apparent massiveness, and though composed of very dense bone, it is liable to fracture, on account of the numerous cavities it contains. In the

The temporal bones weak.

centre is the cavity of the tympanum, Fig. 4 (A), which is separated from the external meatus (B) merely by the membranous drum-head, and which is continued as a small canal, the Eustachian tube (C), to the apex of the bone. The middle ear is a chamber in the substance of the petrous portion of the temporal bone; it is bounded externally by the tympanum, but extends above it, as is shown in Plate IV. Its roof is a very thin plate, separating it from the middle fossa of the skull. This plate shows very clearly the difference in this respect between the external meatus and the middle ear. The latter opens posteriorly into the mastoid cells (D in Fig. 4), which are lined by mucous membrane, continuous, through the Eustachian tube, with that of the pharynx. Inflammation of the middle ear naturally extends to the mastoid cells, some of which are very large; and as these are separated from the cranial cavity by as thin a plate as the middle ear is, we may find pus making its way to the brain. The inner wall of the tympanum has two openings, one into the vestibule, closed by the incus, and one into the cochlea (E), closed by membrane; but these are points that are to re-

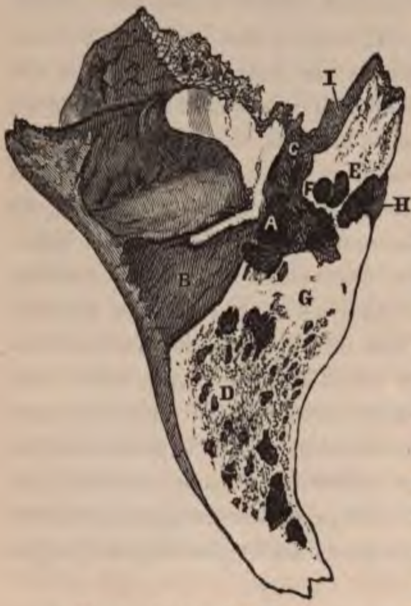

Fig. 4. Section of Temporal.

ceive merely mention, according to the plan of this work. The tympanic cavity is narrow and deep; anteriorly it becomes more shallow and funnel shaped, gradually nar-narrowing in fact, into the bony part of the Eustachian tube. The inner ear is situated in the solid bone internally to the middle ear. It is contained in three cavities, the vestibule (F) [1] with the cochlea in front and the semicircular canals (G) behind. Running from the inner surface of the bone is the internal meatus (H), which all but opens into the vestibule and cochlea. Fig. 4 shows more plainly than words can tell how little there is wanting to form a canal directly through the temporal bone. The bone is further weakened by the carotid canal (I) that runs up through the front part of the petrous portion beside the cochlea and behind the beginning of the Eustachian tube; it turns forward in the bone, and then runs parallel to the tube on its inner side. In Plate IV. these relations are shown on both sides; on the left we have the vertical part of the artery, and on the right the horizontal. The internal meatus contains the facial and auditory nerves; the latter lying below, enters the bone through several small openings and is distributed to the middle ear, but the facial enters a canal known as the aqueduct of Fallopius, which at first runs inward above the vestibule and then turns suddenly backward, and at the same time downward, to open at the stylo-mastoid foramen. This part of its course is seen in Plate V. at 10. At the point where it suddenly changes its course, the nerve has a swelling called the geniculate ganglion, and fibres run from it through the hiatus Fallopii into the cavity of the cranium, and thence through the middle lacerated foramen and the Vidian canal to the spheno-palatine ganglion; this bunch of fibres is the superficial petrosal nerve. The geniculate ganglion is also joined by Jacobson's branch of the glosso-pharyngeal and filaments of the sympathetic. Shortly before reaching the stylo-mastoid foramen, the facial gives off the very remarkable chorda tympani that enters almost at once the back of the tympanic cavity, and passes through it, inclosed in a sheath of mucous membrane, to escape by the inner end of the fissure of Glaser. It joins the gustatory near the head of the jaw. The nerves as they enter the internal meatus are surrounded with a sheath, inclosing cerebro-spinal fluid, which, escaping by the ear, indicates a fracture of the base. It is of course a most serious symptom, but it must be remembered that if the membrane of the tympanum be ruptured there is but very little destruction of bone required to afford a passage to the open air to the fluid in the internal meatus. In certain exceedingly exceptional cases, therefore, this symptom may occur without fatal result. Bleeding from the ear, after a fall, if accompanied with unconsciousness, is also serious, but less so than the appearance of a serous fluid; for the middle and outer ear are supplied by several small arteries, the chief being the tympanic from the facial, which may be ruptured without severe injury.

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[1] The letter F is on front of the vestibule, which is the dark spot behind the cochlea. The section has struck the fenestra rotunda, the edges of which are somewhat broken, and thus the figure shows the vestibule apparently continuous with the cavity of the tympanum. The letter G has sections of the semicircular canals on its inner side and behind it. The descending portion of the aqueduct of Fallopius is between G and the tympanic cavity.

Escape of fluid and blood from ear as a symptom.

The middle fossa has several openings for nerves beside the sphenoidal fissure which opens into the orbit under the lesser wing of the sphenoid. Just outside of the end of this lesser wing, the posterior border of the horizontal plate of the frontal continues the ridges to the side of the skull against the greater wing of the sphenoid, and owing to the prismatic shape of the latter at the junction of its temporal and orbital border, the outer part of this ridge, and especially the greater wing under it, is a firm support. The vault of the skull is strengthened by two median antero-posterior ridges at the two ends of the superior longitudinal sinus. The anterior arises at the base of the forehead, just on front of the foramen cæcum at which the sinus begins, and is lost two or three inches higher. It corresponds to the back of the septum between the frontal sinuses. The posterior ridge begins at the apex of the occipital bone and becomes thicker and stronger till it reaches the internal occipital protuberance, where the skull is often an inch thick. The ridge then gradually subsides to the border of the foramen magnum. Between these two ridges, especially at the line of union of the parietals, the sinus is a groove that diminishes the thickness of the skull; but there is a compensation by a thickening at the two edges of the groove. In the occipital region there is also a thickening corresponding to the superior curved line and the beginning of the lateral sinuses running out from each side of the occipital protuberance. The front part of the skull is further strengthened by the common anterior ends of the temporal lines that run down into the external angular process of the frontal. The zygoma may also give some support, but its chief value is for the face.

Strengthening ridges.

By holding a bisected skull to the light it is easy to see the parts where the vault is thinnest. The most marked place is at the side of the middle fossa which is formed by the squamous part of the temporal and the posterior portion of the great wing of the sphenoid. The part of the anterior fossa that corresponds to the temporal region is also very thin, and still thinner are the two layers of bone that

Thinness of certain parts.

form the walls of the frontal sinus. In the posterior fossa the parts of the occipital that look downward are very translucent except where the ridges occur. In the parietal region the skull is everywhere thicker than at the places just mentioned; but it is interesting to notice that the thinnest parts in the adult were the thickest in the infant; namely, the parietal protuberances. It should be noticed that the thinnest portions are where the wall is double, as at the frontal sinuses, or where it is covered by muscle. The vault of the cranium is elastic and very strong. The result of its construction is such as to favor the dispersion of force from blows; but when the force is sufficient to break, it is found that though the base may be most extensively injured, there is always a fracture at the point struck. Thus the theory of fractures by contrecoup is no longer accepted. It is instructive to notice that the bones are interlocked at the sutures in a way to oppose the driving in or tearing off of any bone by force acting in a single direction. The sagittal suture is formed by prominent serrations of the same character on both sides; but in the coronal the frontal slightly overlaps the parietals above and is decidedly overlapped by them below. Little can be said about the lambdoidal, as it is rather variable and frequently contains Wormian bones. The squamous portion of the temporal simply lies upon the lower border of the parietal, but at the suture between the mastoid portion and the parietal the latter is superficial and the bones are firmly interwoven. The bone is made still more secure by the way in which at the zygoma the temporal lies on the malar, which at the side of the face lies in turn on the maxillary. This arrangement is of course of use only while the sutures are open.

Sutures so interlocked as to support the bones while separate.

The time of the closure of the sutures is very variable, and it would be very unsafe to pronounce on the age of a skull from this point alone. Perhaps the process most frequently begins at from forty to forty-five. As a rule the process begins in the sagittal suture. According to Sauvage[1] the closure of the coronal suture begins in the middle and is more perfect on the right side than on the left, while in the lambdoidal it begins at the right end and travels along the suture.

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[1] *Bulletin de la Société de l'Anthropologie*, Paris, June and July, 1870.

CHAPTER II.

THE BRAIN.

The extent of our ignorance.

It is no part of the plan of this work to attempt a detailed, much less a minute, description of the brain, but to consider merely its general construction in a way that it is hoped will give as simple an idea of the plan as its complexity admits of. Indeed, when we appreciate our absolute ignorance of the principle on which the brain exercises its functions, it seems that, except perhaps for such as intend to devote themselves to solving the problem, a minute knowledge of the arrangement of the fibres is just as profitless as one of the muscular fibres of the heart would have been before the discovery of the circulation. It may, for instance, some day be shown that the size and arrangement of the convolutions of the surface of the hemispheres no more affect function than the relative proportions of the lobes of the liver do that of that organ. The problem is hopelessly complicated by the fact that the brain is not only an organ for the development of nervous force and for the reception of sensory impressions, but is also apparently the organ through which the mind acts. Though it is probable that *cœteris paribus* a large brain accompanies more mental power than a small one, the tables compiled by Wagner, and other statistics, show that the brains of many distinguished men were comparatively light, and those of many low and obscure ones very heavy. We are also ignorant to how great an extent the size of the brain may depend upon that of the

Weight.

body. The average weight of the brain of the male is from forty-nine to fifty ounces, and that of the female forty-four.

The brain may be subdivided as follows: into the medulla oblongata; the cerebellum, including the pons Varolii, and the cerebrum; the latter may be subdivided into the deep central part around the aqueduct of Silvius and the third ventricle, and into the hemispheres that cover over all the rest. This latter division is founded on the development; but there are weak places in all systems of classification of the parts of the brain as of everything else.

Medulla oblongata.

The medulla is the continuation of the spinal cord. It becomes broader, is inclined forward as it lies on the basilar portion of the occipital bone, and the columns of the cord become modified. The anterior central fissure becomes more and more shallow, but is continued up to the border of the pons. On each side of it are the anterior pyramids, and external to these the egg-shaped olivary bodies. Farther back are the restiform bodies that run into the cerebellum, forming its inferior peduncles and bounding laterally the cavity of the fourth ventricle, which lies between the medulla on front and below, and the cerebellum behind and above. (See Plate VI.) Two small ridges, the posterior pyramids, appear in the medulla internal to the restiform bodies, and diverging from one another, lie on the floor, as it is called, of the fourth ventricle. At the point of their divergence, on the middle line, is the opening of the central canal of the spinal cord.

Cerebellum.

The cerebellum, which lies above and behind the fourth ventricle, consists of gray matter externally and white internally. Above, its surface is smooth, but higher in the middle than on the sides, corresponding with the tentorium; below, there is a central lobe in a valley formed by the projection of the lateral masses. Each of the lateral lobes is divided into an upper and a lower portion by a horizontal fissure visible behind and at the sides. The cerebellum is subdivided into many lobes; but I shall merely mention two prominent ones overhanging the fourth ventricle, called the tonsils, and two smaller ones, the flocculi, which project outside of the medulla close to the pons, and close to the apparent origin of the pneumogastric between the restiform and olivary bodies. The cerebellum has three pairs of so-called peduncles, consisting of groups of white fibres; the inferior ones connect it with the medulla, the middle ones go to form part of the pons, and a great part of their fibres form a commissure through the pons between the two halves of the cerebellum. The superior peduncles run from under the upper surface of the cerebellum to two pairs of round bodies, the corpora quadrigemina, which are under cover of the lobes of the brain. These peduncles are not in contact, but are joined by a thin layer of nervous tissue called the valve of Vieussens, and with this they complete the roof of the fourth ventricle.

Fourth ventricle.

This cavity may now be more fully described, as follows: it is bounded below and on front by the medulla and the reverse of the pons which constitute its floor; above and behind by the cerebellum; and more anteriorly by the valve of Vieussens and the superior peduncles; on the side by the restiform bodies, part of the pons, and by the lateral lobes of the cerebellum. The side is not closed by nervous matter but completed by membrane, which leaves, however, a small opening to allow the fluid in the sub-arachnoid space to flow into the ventricles. The fourth ventricle is continuous below with the canal of the spinal cord, and above by a narrow passage, the aqueduct of Silvius, which runs above part of the pons and under the corpora quadrigemina, with the third ventricle. Owing to its surface being filled with numerous deep fissures with secondary ones opening into them, the cerebellum on section gives the appearance known as the arbor vitæ. In each lateral lobe, at about the middle, is a curiously folded little layer of gray matter known as the nucleus dentatus. The pons, though white externally, contains collections of gray matter, and though the superficial fibres appear entirely transverse it is pierced by many from the medulla going through it to the brain. The parts just described fill the posterior fossa of the skull and are covered in by the tentorium.

Base of the brain.

Diverging from the anterior border of the pons are two white masses of fibres, the crura cerebri, that are seen on the base of the brain till they plunge into its substance. Each of these is crossed by a small white band, the optic tract, which appear under the temporal lobe, and meeting its fellow forms the optic commissure from which the optic nerves proper diverge. This commissure is situated on the olivary eminence just in front of the sella turcica, and consequently the diamond shaped space, inclosed by the crura and optic tracts, is above the cavity of the sella. It is shut off from it by a fold of dura mater, which is perforated by a small hole which allows the passage of the tube-like infundibulum on which hangs the pituitary body. Behind this are two white balls, the corpora albicantia, and behind them in the angle between the crura, the posterior perforated space. In this angle, also, appear the third pair of nerves, and the fourth winds round the beginning of the crus. On each side of this space are the temporal lobes of the brain that fill the middle fossa of the skull.

On the floor of the anterior fossa we have first the optic commissure, above which is seen the anterior fissure separating the frontal lobes. Lying in the groove over the cribriform plate is the olfactory bulb sending the minute nerves through the foramina. The diverging roots, outer and inner, of this olfactory tract inclose the anterior perforated space, through which pass numerous arteries to the corpora striata. Just outside of this, on the outer and posterior part of the anterior fossa, lies the celebrated third frontal convolution, in the left one of which the faculty of speech has been said to be situated.

The remainder of the surface of the brain consists of gray matter thrown into convolutions. It is divided in the median line by the fissure which contains the falx; at the bottom of this is the corpus callosum, a thick layer of white fibres running transversely and uniting the two hemispheres. Its length is not equal to half that of the brain, as its posterior end barely covers the corpora quadrigemina, and anteriorly when opposite the front of the temporal lobes it curves down and back to end above the optic commissures.

Fissures and lobes.

The hemispheres are usually divided into five lobes: the frontal, parietal, occipital, temporal, and the island of Reil. The following are the more important fissures: that of Silvius, of Rolando, and the parieto-occipital of Ecker. The fissure of Silvius starts below, external to the optic commissures, and runs outward, upward, and backward so as to mark off the temporal lobe. On the outside of the brain it divides into two branches, the chief one of which continues in the course of the original fissure; the anterior, which is much shorter, runs upward into the frontal lobe. The fissure of Rolando runs downward and forward on the outside of the brain, from about the middle of the longitudinal fissure to the posterior branch of that of Silvius. It does not, however, open into either of these fissures, for the two "central" convolutions that bound it are connected both above and below. The parieto-occipital fissure is a very deep cut on the median surface of the brain, which begins at the upper border far back and runs downward and forward underneath the posterior end of the corpus callosum. On the upper and outer surface of the brain it is very slight. The lobes can now be easily understood. All in front of the fissure of Rolando is frontal, the part behind this, on front of the parieto-occipital fissure and for the most part above the fissure of Silvius, is the parietal. The occipital lobe is clearly bounded internally by the parieto-occipital fissure, and quite arbitrarily below and outside by an imaginary line in the plane of the fissure. All on front of this and below the Silvian fissure is the temporal lobe. The island of Reil is between the two branches of the fissure of Silvius, and is seen from below when the temporal lobe is turned back. Above it, inside of the brain, is the corpus striatum.

Inside of brain.

Turning now to the inside of the brain, it is best to go back to the aqueduct of Silvius, or, as it is better to call it, the passage from the fourth to the third ventricle. This is a small canal running above the pons and under the corpora quadrigemina to expand into the third ventricle, which is a cleft between two masses of gray matter, the optic thalami; it descends to the base of the brain, and the canal of the infundibulum, from which hangs the pituitary body, is its deepest part; hence we know that it is above the middle of the diamond space, between the crura cerebri and the optic tracts, and just above the sella turcica. Above, of course, is the corpus callosum, but just under this there is a layer of white matter, the fibres of which run antero-posteriorly, which is called the fornix. The part that forms the roof of the third ventricle is triangular, the apex being in front, and at this apex it splits into two parallel bands, the anterior crura, which, keeping close together, turn downward from under the corpus callosum and thus bound the third ventricle anteriorly. They appear at the base of the brain as the corpora albicantia. Just as these crura turn down from under the corpus callosum there is left a small opening on each side of the middle line between the crura internally and the optic thalami externally, which, together with the upper part of the ventricle, give the appearance of a Y placed transversely, and sometimes each lateral opening, sometimes the whole Y is called the foramen of Monro. This affords communication between the third ventricles and the two symmetrical lateral ones. The optic thalami that form the walls of the third ventricle appear by their outer surfaces, which are covered by gray matter in the inner wall of the lateral ventricles; on front and external to the optic thalami are two gray masses that present on section a striped appearance, and hence are called corpora striata. Both these ganglionic masses appear in the body of the lateral ventricle. These cavities, moreover, present three continuations or horns. The anterior, which runs forward and outward, and the posterior backward and inward, may both be looked upon as cavities dug out in the substance of the ventricles, but the middle or descending cornu, which pursues a spiral descent, at first backward and outward, then forward and inward to the end of the temporal lobe, is of a different formation, as it may be opened simply by separating the convolutions without cutting the brain. The posterior crura of the fornix which run off from it at the back of the third ventricle, where it is intimately connected with the corpus callosum, run down

Foramen of Monro.

the descending cornua as white bands, under the name of the corpora fimbriata. It will be remembered that the anterior crura of the fornix turned suddenly down on front of the third ventricle from under the corpus callosum, and thus there is left a space between these structures through which the bodies of the lateral ventricles would communicate were it not for two very thin layers of nervous tissue interposed between them. These two layers constitute the septum lucidum; they are usually in apposition, but they may be slightly separated by a few drops of fluid. The space between them is absurdly named the fifth ventricle. The transverse fissure of the brain will be considered with the pia mater. All the true ventricles communicate with one another. The two laterals with the third by the foramen of Monro, the third with the fourth by the aqueduct of Silvius, the fourth with the central canal of the spinal cord and with the sub-arachnoid space.

CHAPTER III.

THE MEMBRANES OF THE BRAIN.

THESE are three in number: the pia mater, which is closely adherent to the brain, the dura mater, which lines the skull and sends folds in between certain parts of the brain, and the arachnoid which is a single layer of delicate connective tissue between them. It is convenient to describe the last first. While the name, indicating a resemblance to a spider's web, is very happy, the conception which has prevailed till within a few years, that it is a serous membrane forming a closed sac, is utterly false. It is a net lying over the convolutions, sending occasional prolongations to the pia mater, loosely surrounding the nerves, and dividing into two the space between the skull and the brain. The outer of these is the sub-dural space; the inner the sub-arachnoid.

Arachnoid.

The arachnoid passes over the spaces between the convolutions, thus leaving a space between it and the pia which follows them, and in some places this space which contains the cerebro-spinal fluid is considerable. The largest cavity of this kind is under the middle of the base of the brain about the inter-peduncular space. There are also smaller ones of this nature, on the sides of the medulla, and there is another in the superior longitudinal fissure surrounding the anterior cerebral arteries that lie on the corpus callosum.

Pia mater.

The pia mater is a layer of connective tissue that holds together vast numbers of small arteries and veins that carry on the circulation of the brain.

By means of the vessels that enter the organ, the membrane adheres closely to it, following it in all its folds. It also sends off certain layers that enter the brain and bear the choroid plexuses. The pia mater, as already stated, completes the walls of the fourth ventricle, which is open at the sides, leaving, however, a small opening by which the ventricular cavity communicates with the sub-arachnoid space. On each side also the pia mater sends in a prolongation, forming the choroid plexus of the fourth ventricle. If the cerebellum is allowed to fall downward, the brain being otherwise in a normal position, a large transverse fissure is seen just above the corpora quadrigemina and under the corpus callosum, to which, at this point, the fornix is united. The pia mater from the top of the cerebellum, as well as that from the under side of the posterior part of the hemispheres, runs into this in a fold which soon, however, becomes a single layer which, lying under the fornix, covers the third ventricle. This is called the velum interpositum. It extends laterally from under the fornix into the lateral ventricles, and by unwinding the temporal lobe it is seen to be continuous in the descending horn with the pia of the surface. Along the outer margin of the fold in this horn, lies the choroid plexus of the lateral ventricles, which, following the course of the horn, reaches the body of the ventricle and meets its fellow by passing through the foramen of Monro. Although the velum interpositum extends from the third into the lateral ventricles, it must not be thought that they communicate except by the foramen. This layer, on the contrary, fills up what would be a slit, and each ventricle has its own lining. Two minute coils of vessels on the under side of the velum interpositum form the choroid plexuses of the third ventricle. The pia mater is continued along

Velum interpositum and choroid plexuses.

the nerves, and becomes the neurilemma. Its relations to the arteries are peculiar and important. The fibrous elements are more strongly developed, and form canals, in the middle of which these vessels run into the brain. By injecting from the sub-arachnoid space, these tubes can be demonstrated, and the fluid has been known to appear in the minute cavities held to be lymph spaces, in which the nerve-cells lie.[1] The pia mater contains lymphatics, but their relations are not clearly understood. The sub-arachnoid space might be held to have practically the same relation to the lymph vessels as the peritoneum or pleura, if the spaces around the cerebral vessels are really lymphatic canals.

Dura mater.

The inside of a fresh skull is strikingly different from that of the dry bones. It is lined by the dura mater, a firm, fibrous membrane that apparently takes the place of internal periosteum, and which by means of curtain-like folds serves to support, to protect, and perhaps I may say to suspend the brain. It consists of two layers, which in most places are inseparable, but which diverge to form canals known as sinuses for the venous blood. It is firmly adherent to the base and but loosely to the vault, except in old age, or when there has been chronic congestion, as is usually the cases in the heads of topers. The free surface is covered with a pavement of epithelium. It is pierced by openings for the passage of nerves and for the carotid and vertebral arteries, but is otherwise closed, for the veins open into the sinuses in its thickness, and the sinuses at the base are completely hidden by the internal layer. Several of the nerves run some distance under it, or in its sinuses after piercing it, before leaving the skull. To remove the brain entire, it is unfortunately necessary to divide the tentorium (Plate V. 28, and Plate VI. 20), and it is to be feared that a true idea of its relations is frequently never obtained. It is a transverse fold, including in its attachment the horizontal portion of the transverse sinus and the superior petrosal one which runs in the upper angle of the temporal bone. It forms a partition between the posterior lobes and the cerebellum, and leaves an oval opening for the narrow part of the brain just above the pons to pass through. After leaving the apex of the temporal bone it is continued forward as a fold on each side of the sella turcica, outside of the posterior and inside of the anterior clinoid processes to meet its fellow on front of the olivary eminence. It is to be noted that above the cerebellum it is not horizontal but is very much raised in the middle like a tent. This fold is joined at right angles by another, the falx cerebri, which is quite accurately compared to a sickle. This arises narrow on front from the crista galli, and becoming broader passes backward in the median line between the two lobes of the brain, and turns down behind the corpus callosum to be attached to the upper surface of the tentorium. It contains the superior longitudinal sinus between the folds at its attachment to the bone along the top of the skull, and in its free border the inferior longitudinal sinus which is continued as the straight sinus (Plate VI. 3) in the tentorium. These sinuses meet and give off the lateral sinuses at a dilatation called the torcular Herophili, opposite the internal occipital protuberance. Rüdinger was the first to question the previously universal idea that the longitudinal sinus divided at the torcular Herophili into the two lateral ones. According to Rüdinger the superior, longitudinal sinus runs

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[1] Wagstaffe in St. Thomas Hospital Reports, 1872. Obersteiner, *Berichte der Acad. der Wissenschaften zu Wien,* January, 1870. Riedel, *Archiv für Mikroskopische Anatomie,* Bd. XI. Heft ii. 1875.

Tentorium.

Falx.

Torcular Herophili: Rüdinger's views.

into the larger lateral one and the straight sinus into the other, thus taking the blood from the periphery of the brain, and that from its interior, different ways. It must be remembered, however, that the inferior longitudinal sinus empties into the

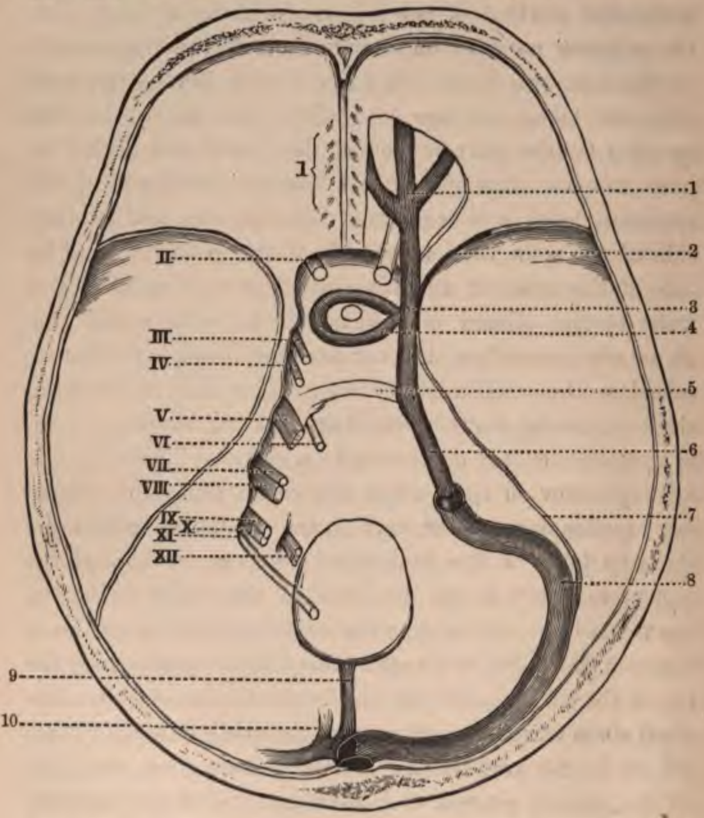

Fig. 5. — The Roman numerals on the left of the diagram indicate the cranial nerves, each being marked by its corresponding number. The Arabic figures are arranged as follows: 1. Ophthalmic vein; 2. Spheno-parietal sinus; 3. Cavernous sinus; 4. Circular sinus; 5. Transverse sinus; 6. Inferior petrosal sinus; 7. Superior petrosal sinus; 8. Lateral sinus; 9. Occipital sinus; 10. Straight sinus opening into the smaller lateral one.

straight one. He admits that there is a constant communication at the torcular between the two channels. For several years I have examined almost every head that I have seen opened for this point, and though I have often seen Rüdinger's arrangement very distinctly, I am inclined to doubt if it exists in more than half the cases. There is no question at all that one lateral sinus and jugular foramen, usually the right one, is larger than the other, as stated on page 19. Fig. 3 represents a by no means uncommon asymmetry. One or two occipital sinuses connect the torcular with the vertebral plexus under the dura mater at the upper end of the spinal canal.

Nerves of dura mater.

There is a small fold called the falx cerebelli, running also in the median line from the posterior part of the under surface of the tentorium to the foramen magnum. On removing the tentorium it is seen that the dura mater runs down like a funnel into the spinal canal. The sella turcica is covered by the dura mater of the middle fossa so as to be completely shut off, except for a small opening large enough to admit the infundibulum, from which the pituitary body hangs. The latter structure, therefore, is in a chamber of its own. On each side of it, under the inner fold of dura mater, is the cavernous sinus which actually contains the carotid artery just after its entrance into the skull, and some nerves. There is also a sinus surrounding the sella, and other small ones that can be seen in Fig. 5. The dura mater is supplied by nerves chiefly from the fifth pair; the first is given off by the first division before it leaves the skull and runs backward to the tentorium and the lateral sinus; it lies close against the fourth pair, from which it has been said to arise. According to Rüdinger, it receives sympathetic fibres. The branch from the second division of the fifth is of little consequence except when it takes the place of that from the third. It is given off in the skull and goes to the middle fossa. The branch from the third division arises outside of the skull, but reënters it through the foramen spinosum, and follows the general distribution of the middle meningeal artery. There is also a recurrent branch of the pneumogastric from the jugular ganglion, which is distributed in the lateral part of the posterior fossa. Dr. W. T. Alexander,[1] who has studied the nerves of the dura with the microscope, finds that they may be divided into two sets: those that follow the vessels and end in their walls, and others that form a network in the substance of the membrane.

Cranial nerves.

The relations of the cranial nerves are as follows: *First Pair.* The olfactory bulbs lie over the cribriform plate on each side of the crista galli, in a deep fossa, and each filament has its own little opening. *Second Pair.* The optic commissure lies on the olivary eminence, and from it diverge the optic nerves to pass out through the optic foramina above and internal to the ophthalmic arteries. They carry with them a prolongation of the dura in the form of a sheath.

Decussation of fibres in chiasma.

The question of the decussation of the fibres in the chiasma is of some practical interest to the ophthalmologist. It was formerly believed that some fibres from each optic tract crossed over to the opposite eye, while other more external ones kept to their original side; also, that there were commissures of fibres between the two tracts at the back of the chiasma, and corresponding ones between the retinæ on front of it. This arrangement was expressed by a charmingly symmetrical diagram made as follows: Draw an X, the branches of which cross at a right angle, and draw a few curved lines along each side. Fifteen years ago, Biesiadecki demonstrated, as he supposed, total decussation; and nine or ten years later other observers came to similar results. The latest and perhaps most convincing observations by Gudden[1] show that in man, and in animals that have a common field of vision for both eyes, there is a partial decussation, and a complete one for those animals with whom the two eyes have separate fields. The anterior commissure between the retinæ has been done away with, and it has been shown that the fibres of the posterior one are separated from the chiasma by a layer of gray matter.[2]

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[1] *Archiv für Mikroskopische Anatomie*, Bd. XI. Heft ii.

The third pair appears at the base of the brain between the crura cerebri, and having passed over the optic tracts pierces the dura mater beside the sella turcica, and thus gets inside of the cavernous sinus. It is fairly inside of the sinus laying above the artery, while the other nerves are in the outer wall of the sinus. (Plate III. 14.)

The fourth pair appears between the outer side of the peduncle and pons, and runs along the margin of the tentorium, which it pierces opposite the sella turcica by a very small opening; it runs along the outer part of the cavernous sinus. (Plate III. 16.)

The fifth pair arises by two roots, the larger sensory and the smaller motor, which reach the surface by piercing the pons. They run along its sides, as seen in Plate IV. 9, and pass through a single hole in the dura of the posterior fossa some half an inch from the posterior clinoid process. It immediately afterwards enlarges into the Gasserian ganglion, which lies on the apex of the petrous portion, and divides into its three terminal branches; the second and third pass almost directly from the ganglion out by the foramen rotundum and ovale respectively, while the first runs in the outer wall of the cavernous sinus. (Plate III. 17.)

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[1] *Archiv für Ophthalmologie,* Bd. XX. Heft ii.

[2] For an admirable account and discussion of this subject, consult Dr. O. F. Wadsworth's Reports on Ophthalmology, in the *Boston Medical and Surgical Journal,* vol. xc. p. 454, and vol. xcii. p. 528.

The sixth pair appears at the back of the pons, between the anterior pyramid and the olivary body, and runs along the basilar portion of the posterior fossa. (Plate IV. 10.) It goes through a small opening in the same antero-posterior plane as the last nerve, but more centrally placed, and then it runs near the outer wall of the cavernous sinus. (Plate III. 15.)

The seventh and eighth pairs appear side by side, between the olivary and restiform bodies, behind the pons. The former is the more internal. They pass through the dura mater together, the facial being above, by an opening corresponding to the internal auditory meatus. (Plate V. 9.)

The ninth, tenth, and eleventh nerves, namely, the glosso-pharyngeal, pneumogastric, and spinal accessory, find exit through the anterior part of the jugular foramen (Plate V. 11), and it may be mentioned that as the lateral sinus is under the dura mater, the opening for the nerves is the only one visible when the membrane is in place. At this exit they are in regular order, from before backward, the first or glosso-pharyngeal being separated from the others by a membranous partition. The ninth and tenth appear in the medulla oblongata, between the olivary and the restiform bodies; the eleventh, or spinal accessory, comes from the lateral column of the cord, and enters the skull through the foramen magnum. (Plate VI. 11.)

The twelfth pair, or hypoglossus, arises between the anterior pyramid and the olivary body, and passes in two bundles on each side through openings in the dura mater corresponding to the anterior condyloid foramina. (Plate V. 13.) It occasionally happens that the foramen in the bone is also subdivided.

CHAPTER IV.

THE SKELETON OF THE FACE.

THE parts of the face will be considered, with the various cavities and regions they assist in forming, so that a general sketch is all that is necessary here. The prime object of the face is to form the jaws, but it also has chambers for the organs of sight and smell. The upper jaw is formed by two symmetrical bones that are strong only in the parts that support the teeth, and in the front of the hard palate. Between them is the nasal cavity, subdivided by a median partition, and above each, the orbit of the corresponding side. They are hollow, containing cavities opening into the nasal chambers. They are supported behind by the pterygoid processes of the sphenoid, the palatal bones being interposed, and they receive firm support by the malar bones that form the front of the outer wall of the orbit, and run into the zygoma. The amount of injury that the face may suffer from violence or surgical interference without loss of life, is very remarkable. The lower jaw is formed of two symmetrical bones that unite early into one, and it is attached to the skull solely by ligaments and muscles. The head fits into the glenoid cavity at the origin of the zygoma just on front of the auditory meatus. The coronoid fossa for the attachment of the temporal muscle is under cover of the zygoma. The angle of the jaw, on the average about 110°, is subject to considerable variations, and is much more obtuse in childhood, when the jaw contains but few teeth, and in

Lower jaw

old age, when many are gone, than in the prime of life. This is a point of considerable surgical significance, as the square jaw covers the important parts behind it much more than the obtuse one.

The lower jaw is a very firm bone, although the horizontal part is weakened by the canal for the artery and nerve that runs through it. It is considerably thickened to give room for the sockets of the teeth. This thickening projects inside and overhangs the mylo-hyoid ridge. In the middle line it is very thick by the presence of tubercles on the inside, as well as by its projection forward. The anterior border of the ascending ramus is continued down across the jaw, as a ridge which must greatly strengthen it. The three foramina for the terminations of the respective divisions of the fifth pair of nerves are nearly in a vertical line, but the mental and sometimes the infra-orbital are found farther out than the supra-orbital.

Space behind the face.

A side view of the skull, attached to the vertebral column, shows a space bounded behind by the latter, above by the base of the skull, to wit, by the basilar process and the petrous portions, on the sides by the vertical portions of the lower jaw, and on front by the face. The middle of this, *i. e.*, the part under the basilar process, is occupied by the pharynx, which is a muscular bag lined with mucous membrane and opening on the front into the nose and mouth, and below into the gullet and wind-pipe. On each side of this internal to the styloid process is a space occupied by the internal carotid artery, the internal jugular vein, and the nerves issuing from the base of the skull. Outside of this, behind the ramus of the jaw, is the parotid region occupied by the gland of that name. The cavity on the side above the zygoma is the temporal fossa, and that below it the zygomatic. On the skull these are large spaces, but in life quite filled by soft parts, chiefly by muscles. The zygomatic fossa has at its depths the outer plate of the pterygoid process, and between this and the upper jaw is the vertical pterygo-maxillary fissure. Another nearly horizontal fissure, the spheno-maxillary which opens into the outer side of the orbit, strikes the upper end of the former fissure at an angle. In removing the upper jaw the bone must be cut through into this fissure. Just inside of the point of junction of the pterygo-maxillary and the spheno-maxillary fissure, and therefore just in front of the base of the pterygoid processes, and behind and before the orbit, is a small cavity known as the spheno-maxillary fossa. This is thought very difficult to understand, but it need not be so. Introduce a probe from the zygomatic fossa into the orbit through the spheno-maxillary fissure, carry it inward to its inner end, and it will pass through the fossa. In it lies Meckel's ganglion, and the foramen rotundum opens into it from the middle fossa of the skull transmitting the second division of the fifth pair of nerves. On its inner side is a round opening, the spheno-palatine foramen, in the skeleton, which in life just transmits a nerve from the ganglion to the nasal cavity. Below the fossa runs down like a funnel into the posterior palatine canal, which passes through the back and outer angles of the hard palate. Behind, below the foramen ovale is the Vidian canal, through the root of the pterygoid process. I merely mention for completeness the utterly unimportant pterygo-palatine foramen.

Spheno-maxillary fossa.

The hyoid bone is really a part of the face, though usually described with the neck. Its chief purpose is to give origin to muscles forming a part of the tongue, and to give it a firm but movable base of

Hyoid.

support; it is suspended by the stylo-hyoid ligaments running from the styloid processes to its lesser horns, and by various muscles. Though freely movable, it must be remembered that, while certain muscles hold it in place, it may serve practically as a point of departure for the action of others. When the head is in the usual position it is a finger breadth below the level of the jaw, and its body is about four fingers' breadths behind the symphysis; but when the head is thrown back this distance may be increased by the breadth of another finger.

CHAPTER V.

THE SUPERFICIAL PARTS OF THE HEAD AND FACE.

THE hairy scalp, though continuous with the skin, differs from it in important respects. It descends for a varying distance on the forehead, and upon this, far more than on the bony outline, depends the apparent length or shortness of the face. The subcutaneous tissue under the scalp is closely adherent to it as well as to the aponeurosis below, and is subdivided into small chambers, containing more or less fat, by numerous fibrous partitions. It adheres to the walls of the vessels that ramify in it, thus opposing the tendency which they would otherwise have, to fall together when cut or ruptured, and the partitions just mentioned favor the formation of circumscribed effusions. This subcutaneous layer loses these characteristics as it leaves the top of the head. They exist in the frontal region, but are not so strongly marked. In the face, directly under the skin, there is a considerable layer of fat, which disappears in the skin over the nose and in the eyelids proper. There is no distinct fascia about the face except the masseteric over the masseter, and that under the chin. Other points concerning the integument of the face will be discussed in more detail with that region. At the back of the head the skin leaves the skull opposite the superior occipital ridge to pass down over the muscles of the neck. The scalp and subcutaneous tissue change into ordinary underlying tissue on the side of the head above and around the insertion of the ear. On the

Occipito-frontalis.

top of the head, under these two layers, is a distinct aponeurosis, commonly called the tendon of the occipito-frontalis. These muscles, however, have no kind of relation to one another except that of being inserted into the two ends of this fascia. The former arises from the superior occipital ridge; the latter has but slight bony attachments and joins the muscles of the face. It should be classed among the muscles of expression, and, like them, is supplied by the facial nerve. The aponeurosis becomes thinner at the side of the head, and, passing down over the zygoma, is lost in the subcutaneous tissue. The anterior and superior muscles of the ear have been described as inserted into it, but they really lie on its outer surface. They are, however, so intimately connected with it that the preceding statement is practically no great error. This aponeurosis, being intimately connected with the scalp, is removed with it in scalping, be it done by an Indian or by machinery. Under it is the fourth layer consisting of areolar tissue, which may be divided into various laminæ. It is but loosely attached to the aponeurosis above or to the periosteum below, so that it allows fluid to spread freely over the skull. On the side where it rests, above the temporal muscle and proper temporal fascia, it goes to be lost in the cheek. I am inclined to believe that it is a deep layer of this tissue that is attached to the superior temporal line forming the superficial temporal fascia, which is but very slightly if at all connected with the zygoma. This view as to its origin I believe is in accordance with that of von Jhering (*vide* p.15); but, like him, I have not been able to examine the point sufficiently frequently to be certain. The fifth layer is the periosteum, which is not very firmly fastened to the bone. The union is strongest along the sutures while these persist. I am

Superficial temporal fascia.

unable to find Tillaux's subperiosteal layer. On the side of the skull we have additional layers, owing to the presence of the temporal muscle which arises from the inferior curved line from the inside of the fossa.

Temporal fascia and muscle.

The temporal fascia arises from the whole length of the curved line from its origin at the external angular process, and being inserted into the zygoma shuts off by a firm curtain the temporal fossa from the surface of the head. It is evident that while the fascia and bone are intact any fluid in this space will tend to escape downward and not outward through the skin. Though arising single this fascia splits into two, and each layer is inserted into an edge of the zygoma. The space between them is filled with fat, and there is also fat between the inner layer and the temporal muscle. (Plate II.) This arises chiefly from the bony inner wall of the cavity and also from the inner side of the temporal fascia, occasionally also from the zygoma. The last group of fibres are often continuous with those of the masseter. In short, this muscle arises from nearly the whole of the temporal fossa except its anterior walls. The direction of the fibres is downward and forward to the coronoid process of the lower jaw. The details of the insertion will be considered in another connection. If a pin be stuck in on front of the ear above the zygoma it will pass through the following layers: 1st, the skin; 2d, the subcutaneous tissue; 3d, the anterior muscle of the ear; 4th, the lateral part of the occipito-frontal aponeurosis, here very thin; 5th, the loose areolar tissue under it (in this there may be a layer coming from the superior line, the superficial temporal fascia); 6th, the outer layer of the temporal fascia; 7th, fat; 8th, the inner layer; 9th, fat; 10th, the temporal muscle; 11th, periosteum; 12th, bone.

Layers in temporal region.

Fasciæ of neck.

The true fascia that comes from the back of the neck arises from the ligamentum nuchæ, incloses the trapezius, unites on front of it, splits to inclose the sterno-mastoid, again unites and again splits to form the sheath of the parotid gland. The two layers meet on front of the gland and join the fascia covering the masseter. Other fasciæ and further details will come with the different regions.

Arteries and veins of outside of vault.

The vascular supply of the vault comes chiefly from the superficial temporal arteries, branches of the artery of that name; they are two or three on each side and rather variable. The main trunk is given off inside the parotid gland, and becoming superficial passes over the zygoma on front of the ear, where it is readily felt. These are assisted in supplying the vault by the insignificant posterior auricular and by the termination of the occipital; this lies deep during nearly the whole of its course, and is important for the anastomoses which its early branches make with others from the subclavian and its terminal ones with the temporal. The supra-orbital and frontal branches from the ophthalmic, the termination of the internal carotid, render some slight assistance in the forehead. The temporal veins take the blood from nearly the whole of the outside of the head, and ultimately form the external jugular vein. It may be as well to repeat that almost the whole of the blood on the outside of the top of the head circulates in the subcutaneous layer.

Lymphatics.

The lymphatics of the head are numerous. The occipital set run back from the top of the head to the gland situated in the occipital region. Those of the front and side of the head cannot be very distinctly separated from one another; they converge to glands in the parotid region and at the front and back of the sterno-mastoid.

The nervous supply is derived from branches of the first division of the fifth pair, the frontal and supra-orbital, which are much larger than the corresponding arteries, and carry sensation, and often neuralgia, as high as the vertex; from the auriculo-temporal branch of the third division of the fifth pair, which crosses the zygoma near the temporal artery and is spread out over the side of the head, from the great auricular and small occipital nerve, of the cervical plexus that are distributed behind the ear, and from the great occipital which is the internal branch of the posterior division of the second cervical nerve, which is distributed in the occipital region and supplies with the facial the posterior belly of the occipito-frontalis. The anterior belly is supplied by the facial. The temporal muscle is supplied by the deep temporal nerves from the motor part of the third division of the fifth pair.[1]

Nerves.

The skin of the forehead is closely attached to the muscles below it, and is easily thrown into folds by their contraction. Sebaceous glands are numerous and sweat ones still more so. The eyebrows correspond to the upper border of the orbit. Humphry suggests that they carry the sweat from the eyes off to the side of the face. They are over the upper part of the orbicularis muscle and afford much protection to the eye. The movement of bringing the eyebrows downward serves to shut off much light that would dazzle the eye, when it is necessary that the lid should be raised.

Skin of forehead.

The prominences above the orbits are caused by the frontal sinuses, cavities situated between the two plates of the frontal bone. They are usually divided by a partition near the middle line, but sometimes

Frontal sinuses.

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[1] A diagrammatic view of the distribution of the cutaneous nerves is given in Fig. 10, p. 128.

there is but one. They open on each side into the middle meatus of the nose by a canal called the infundibulum. (Plate I. 4.) They are lined with mucous membrane continuous with that of the nose, and said to be ciliated. Inflammations may extend into them from the nose, and they may be reached by insects which may deposit eggs in them. The bony plates inclosing these cavities are very thin. Their size is very variable. In the ridge inside the skull to which the dura mater is attached is seen the foramen cæcum (Plate I. 2), which in the adult is the end of the superior longitudinal sinus, but in the infant forms a venous communication between the nose and the brain.

CHAPTER VI.

THE ORBIT.

THE upper border of the orbit is decidedly curved, and bends down at the outer angle, though the roof of the orbit itself is nearly horizontal. At about the inner third of this border is the notch or foramen for the supra-orbital artery and nerve. The former of these comes from the internal carotid, the latter from the first division of the fifth pair of nerves, and supplies sensibility to the integument as high as the coronal suture. It is assisted by the supra-trochlear branch of the same nerve. The frontalis, orbicularis, and little corrugator supercilii, are supplied by the facial, the fine filaments of which anastomose with those of the ophthalmic.

Walls of the orbits.

The orbits are pyramidal-shaped cavities inclosing the eyes. The roof is formed by the frontal, and far back by the small wing of the sphenoid; both are very thin. Below they are smooth, but in the cavity of the skull the frontal is covered with irregular ridges. The outer side is formed by the great wing of the sphenoid, and on front by the malar bone, which forms also a part of the floor. The inner side is formed by the os planum, or orbital plate of the ethmoid, which is very thin, and on front of it, between it and the ascending process of the upper jaw, is the lachrymal, which together with the latter forms a groove, which runs into the lachrymal canal that opens into the nasal cavity. (Plate I. 17.) The floor is chiefly formed by the superior maxilla, and far

Eyelids.

back there comes in a little piece of the palatal.[1] The nose, which projects on the inner side, and the malar on the outer, afford a great protection to the eye. The upper and lower borders are also strong, but otherwise the walls of the orbit are very delicate. The inferior part of the three frontal convolutions rest on its roof. The inner walls of the two orbits are parallel to one another, being separated merely by the ethmoid. The outer walls diverge greatly, so that if continued backward they would form almost a right angle with each other. At the back of the orbit and high up is the optic foramen, transmitting the optic nerve and ophthalmic artery. Running downward and inward is the sphenoidal fissure, between the greater and lesser wings of the sphenoid, transmitting the third, fourth, the first part of the fifth, and the sixth pairs of nerves and the ophthalmic vein. Running toward the lower end of this is the spheno-maxillary fissure opening into the zygomatic fossa. The entrance of the orbit is guarded by the lids, which have a far more important purpose than merely to exclude the light at night, or foreign bodies that the eye may see endangering it. They are closed several times a minute, and thus keep the front of the eye moist by carrying over it the tears that are running along the borders of the lids. The upper lid is the larger, but they are essentially similar in structure. There is exceedingly little connective tissue under the skin, which is in contact with the orbicularis muscle. This muscle is divided into two parts: one in immediate connection with the lids, and one extending to the edge of the orbit. The two ends of the space left between the lids differ by the inner side being elongated.

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[1] Professor Harrison Allen has written an account of a number of anomalies in the construction of the orbit, in *The American Journal of the Medical Sciences* for January, 1870.

There is some connective tissue, though but very little, between the cartilage and the muscle. The cartilage is attached by a pretty firm layer of fibrous tissue to the border of the orbit, to shut off the inside of that cavity, so that effusions of blood under the occipito-frontalis or orblicularis form ecchymosis under the skin of the eyelids, and not under the conjunctiva lining them. Thus we have from the outside of the lid to the inside, skin, muscle, areolar tissue, cartilage, and conjunctiva, which is a modified mucous membrane. This is continued on to the free edge of the lid, where it passes into the skin. The free edge shows two lines of distinct structure; the more external just under the lid is the line of eyelashes, and that just within it is the line of the orifices of the Meibomian glands which extend behind the cartilage. It is possible for a skillful operator to split the edge of the lid between the lashes and glands without doing injury to either. Near the inner ends of the lids are two minute openings which collect the tears, and lead them through a canal in each lid to the lachrymal sac. But before discussing this we must consider the palpebral ligament, which is a well-marked tendinous band, running from the inner angle of the eye to the margin of the orbit, just in front of the lachrymal sac. From this ligament there spreads out a fascia over the sac. Part of the orbicularis is inserted into this tendon, and is known as the tensor tarsi. It is very rare to find an individual who can command its action, which is to narrow the slit of the eyelids by drawing their inner ends toward the nose.

Conjunctiva.

The conjunctiva is reflected from the inside of the lids to the globe of the eye far enough from the cornea to cover the insertions of the muscles. Thus it is evident that to reach any of the structures in the orbit, if we enter between the eyelids, the conjunctiva must first be divided, and on the other hand it is possible to enter the orbit by cutting through the origin of the lids without interfering with it. In the inner canthus of the eye there is a vertical fold of conjunctiva called the plica semilunaris, and inside of this a little red swelling caused by glandular follicles called the caruncula lacrymalis. There is a fossa in the bony walls of the orbit at the upper and outer border which contains the lachrymal gland that secretes the tears. This is behind the conjunctiva, which it pierces by some dozen minute orifices. The tears pass insensibly across, assisted, as already stated, by the unconscious winking, and are gathered by the lachrymal canals into the sac. This extends as the duct (Plate I. 17) down a canal in the bones from the orbit to the inferior meatus, where the tears pass off under cover of the inferior turbinated bone. The sac is the dilated upper portion that lies in the orbit inside the inner angle of the eye. By pulling the lids outward, the tendon of the lids, which crosses about the middle of the sac, is made tense. Various valves have been described by various authors and utterly denied by others. They have been said to be at the entrance of the canals into the sac, at the junction of the sac and the duct, and near the opening of the latter. There is no doubt that they are all very variable. The one which I have found most constantly is that of Foltz between the sac and the duct. I cannot remember ever having seen the valve said to exist near the lower opening of the latter. This opening is usually a vertical slit, which is not an arrangement favorable for regurgitation. The course of the nasal duct is downward, outward, and backward.

Lachrymal sac and duct.

We have seen that the anterior part of the orbit is shut off from the posterior by the conjunctiva; but this division is made more firm, and other

Capsule of Tenon.

purposes answered by another membrane that lines the deep division — the capsule of Tenon. This has been described in various ways, and the following plan, which is essentially that of Sappey and Tillaux, has been decided on after several dissections. The periosteum of the orbit is but very loosely attached to the bones, and from the borders of the orbit there goes off from it a layer of cellular tissue hardly dense enough to be called an aponeurosis, that forms a cup-shaped depression in which the globe of the eye rests. It is continued to the back of the orbit around the optic nerve, thus making a separate chamber for all the contents of the orbit, with the following exceptions: 1st, the eye itself; 2d, a certain amount of areolar tissue between this capsule and the conjunctiva; 3d, the lachrymal gland that lies in a capsule of its own, formed, it may be said, by an additional layer of this capsule, — Tillaux points out that the gland can be removed without injury either to the conjunctiva or the capsule of Tenon, provided, of course, the incision be made above the eyelid so as to [illegible] the conjunctiva; 4th, the muscles of the orbit which are [illegible] of the cavity of the capsule of Tenon [illegible] outside of the cavity of the periosteum. The capsule sends off [illegible] prolongations [illegible] that bind them to the walls of the orbit [illegible] or nothing of [illegible] by which this is said to be formed.

The [illegible] or form [illegible] been [illegible] as a [illegible] tive of the [illegible] of the globe [illegible] breaking [illegible] the conjunctiva and capsule of Tenon, or indeed those behind the latter, as blood will make its way through it. This may extend under the palpebral conjunctiva if the blow be very severe, and will be likely to do so quickly if it does at all. If there is a fracture of the base of the skull the blood will break through Tenon's capsule and appear on the globe, and then may work its way still farther forward under the palpebral conjunctiva. It is difficult to see how it should reach the outside of the lids, unless it passes through the tissues and muscles at the border of the orbit. The following conclusions are those given by Dr. R. M. Hodges, in an admirable lecture on the subject.[1]

Conclusions of Dr. R. M. Hodges.

"1. That an effusion of blood beneath the integuments of the skull, if it does not gravitate backward, often produces an ecchymosis in the cutaneous surface of the eyelids, but never of the conjunctiva of the lids or globe.

"2. That a blow directly upon the eyeball may give rise to an ecchymosis of the conjunctiva, both of the globe and lids.

"3. That when fracture of the base of the skull is indicated by ecchymosis, this ecchymosis appears first beneath the conjunctiva of the globe, then beneath the palpebral conjunctiva, and only subsequently in the integument of the eyelids, if at all.

"4. That when the injury has been such as to make a fracture probable, external ecchymosis of the lower lid, and less frequently of the upper lid, is a significant symptom, only when it accompanies ecchymosis of the globe, or follows it, after an interval."

Optic nerve.

As the eyes look straight forward, and not in the line of the axis of the orbit, the optic nerve, in order not to enter the globe at an angle, and also to permit its free movement, is not tense, but lies loose and somewhat wavy in the fat that fills the orbit; the artery quickly leaves it and keeps nearer to the roof of the orbit.

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[1] *Boston Medical and Surgical Journal*, April 17, 1873.

The large size of the optic nerve in the orbit is greatly due to the sheath, which is a prolongation of the dura mater, forming a tube around the nerve proper, which is itself encased in a sheath from the pia mater. Between this and the dura there is a cavity. This may be very prettily demonstrated by removing the roof of the orbit and the top of the optic foramen and laying bare the nerve. Then, at the optic foramen, lay open the sheath of dura mater with the scissors by a cut along its top and throw back its sides. Then, if the nerve is thrown out of the sheath, it is seen that this is a perfectly uninterrupted continuation of the dura that covers the olivary eminence.

Muscles of orbit.

As to the muscles of the orbit: there is the levator palpebræ that runs in the roof of the orbit and raises the lid, being inserted into the upper border of the cartilage. This is supplied by the third pair, and thus when the eye cannot be closed, owing to paralysis of the seventh, which supplies all the other muscles of the lids, the upper lid may nevertheless be raised higher than its usual level. Of the four recti, all but the upper arise by a common tendon around the lower three quarters of the optic foramen; the outer one, however, has another head from the lower or outer margin of the sphenoidal fissure. The upper rectus arises just above the optic foramen. These are inclosed in the sheaths already mentioned, from which prolongations pass to the walls of the orbit, thus keeping the muscles in place. They become tendinous, and are inserted into the sclerotic, but not at equal distances from the cornea. The inner is the nearest, the lower next, then the outer, and finally the upper. Thus their insertions would take place in a spiral around the cornea. The inner is about five millimeters from it, and the upper eight or nine millimeters. In considering the action of these muscles, it is essential to remember the difference between the axis of the globe and that of the orbit. The axis of the eye is antero-posterior, that of the orbit divergent. The superior and inferior recti run in the line of the latter and obliquely to the former; thus they do not give the eye a simple movement, like the inner and outer recti, but as they draw it upward or downward, roll in inward as well. Hence, of the four straight muscles, three give the eye more or less of an inward inclination. Of the oblique muscles, the lower arises from the front of the floor of the orbit behind the lachrymal groove, and runs backward and outward to be inserted into the eye midway between the lower and outer rectus, and into the posterior half. This point is important; it follows from it, that as the muscle draws the point of its insertion downward, forward, and inward, it rolls the cornea upward, backward, and outward. The superior oblique quite unaccountably arises from the back of the orbit, and runs forward to the inner upper angle of the orbit, where it changes its direction by passing through a pulley; and it is from this point that, mechanically speaking, it takes origin. It then goes backward and outward, and is inserted on the outer and upper side, and just behind the equator; thus this rolls the cornea downward and outward. Both the oblique muscles lie between the globe and the straight muscles crossing them. They both roll the cornea outward, and they both have a tendency to pull the eye forward. I believe this last function is of great importance; for, although the direction of the straight muscles is somewhat changed by the bands that hold their sheaths to the orbit, yet it is certainly probable that these muscles, which dur-

Oblique muscles roll eye outward and oppose retraction.

ing the waking moments are never at rest, would, in the course of a life-time, pull the eye back into the orbit if they did not have some equally active antagonists. The motions imparted by the muscles of the eye are numberless and indefinable; for it is to be remembered that not only one, but several of them, may act at once, but also they must act when the cornea is looking in any possible direction, and thus the combinations of movements that they may cause is infinite.

Nerves of orbit.

The nerves of the orbit need not be discussed in great detail. We have the third pair supplying all the muscles except the external rectus that is supplied by the sixth, which, by the by, is the largest motor nerve in proportion to the muscle it supplies in the body, and the inferior oblique that is supplied by the fourth.

The fifth pair deserves a somewhat more careful description. This divides into three branches before entering the orbit; the most important of these surgically, as it is occasionally resected for neuralgia, is the *frontal*, which runs forward to the supra-orbital foramen, immediately under the periosteum of the orbit and above the levator palpebræ. About midway forward it gives off the supra-trochlea branch, which runs to the inner side of the orbit, gives filaments to the forehead and to the inner part of the upper eyelid. The *lachrymal* runs along the outer side of the orbit and supplies the gland, and ends in the eyelid. The third branch is the *nasal*, or, as it is more appropriately called by the German anatomists, the naso-ciliary, which gives two or three long ciliary nerves, a branch to the lenticular ganglion, and going through a minute foramen between the ethmoid and frontal enters the cranial cavity, gives fibres to the dura, and then, going through a small opening at the side of the crista galli, enters the nose and gives a branch to the mucous membrane, while another makes its way out to end on the skin near the tip of the nose. There remains the lenticular ganglion which presides over the accommodation of the eye. It is in the back part of the orbit, at the outer side of, and very near, the optic nerve. It receives its motor root from the third, its sensory from the naso-ciliary, its sympathetic from the cavernous plexus which sends several branches into the orbit, which have rather irregular connections with most of the nerves. The branches of the ganglion, some six to ten in number (Henle), are called the short ciliary nerves, and are arrayed with the long ones about the optic nerve. They subdivide so that they may be twice as numerous when they reach the globe, which they enter around the optic nerve. They are finally distributed to the ciliary muscle, iris, and cornea. They are very sensitive, and their division is always accomplished, as soon as possible, in enucleation, when performed by operators who are ignorant of ether, and justly fear chloroform.

Lenticular ganglion.

The arteries come from the ophthalmic, and form important anastomoses with the facial and internal maxillary, but otherwise do not require much description. The arrangement of most of them is very similar to that of the branches of the fifth pair, and beside these are branches supplying the muscles. The eye is provided for by the central artery of the retina, which comes directly from the main artery. There are also posterior ciliary arteries, which enter near the optic nerve, and send some branches to those which the central artery gives off in the nerve, before entering the field of their main disbribution in the choroid. Besides these, the muscular branches send off the anterior ciliary arteries, which supply the conjunctiva, and pierce the sclerotic

Circulation of orbit.

near the cornea, going to the iris and freely anastomosing with the posterior ciliary vessels. There is always at least one branch of the middle meningeal artery in the outer part of the orbit, which it enters through the sphenoidal fissure, anastomosing with branches of the ophthalmic; and Zuckerkandl[1] has reported four cases in which the middle meningeal arose from the ophthalmic in the orbit. This arrangement is of importance in insuring the supply of blood to the eye, should any injury happen to any of the branches of the ophthalmic, and perhaps even in case of obstruction in the artery itself.

Veins in free communication with those of cranium.

Occasional communication with pterygoid plexus.

The veins of the orbit are interesting from their influence on the intra-cranial circulation. Though the course of the blood is generally held to be inward, there is no doubt that it may be the other way, thus affording a valuable outlet, as the anastomeses with the facial vein are very free. Besides the smaller branches, which correspond in the main to the arteries, we have the ophthalmic vein, which is either single or is replaced by two trunks, a superior and an inferior, which open into the sinus cavernosus by passing through the sphenoidal fissure. The inferior sometimes passes through the spheno-maxillary fissure into the pterygoid plexus, and then the course of its blood must, as a rule, be from the orbit. A small communicating vein through this fissure is very common. It is to be noticed that there is always a communication between the two opthalmic veins, whether they ultimately form one trunk or not. An important, but by no means constant vein, is the ophthalmo-meningea, described by Hyrtl, which may run from the neighborhood of the fissure of Silvius through the sphenoidal fissure into the orbit, communicating with its veins. This is sometimes without valves, and then, no doubt, may carry blood from the brain; but, curiously enough, when valves are present they are so turned as to prevent the flow of blood in that direction. The central vein of the retina empties either directly into the cavernous sinus — the usual plan — or into the opthalmic vein, according to Sesemann, who has studied the veins of the orbit very thoroughly.[1] It always has a lateral diverging branch, so as to make the escape of blood from the retina independent of the state of a single vein or sinus. In short, apart from the importance of forming a safety valve for the brain, the veins of the orbit are so arranged that the blood from the eye may be carried off entirely through the superficial and deep veins of the face.

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[1] *Medicinische Jahrbücher*, 1876, Heft iii.

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[1] Reichert and Du Bois Reymond's *Archiv*, 1869.

CHAPTER VII.

THE NOSE AND NEIGHBORING CAVITIES.

THE position of the nose itself does not need description, but something may be said of that of the nasal cavity. It is divided in the middle by the septum, and opens on front through the nostrils and behind through two larger openings, the posterior nares, into the pharynx. It is bounded below by the hard palate, and is narrow above where it lies under the cribriform plate and part of the body of the sphenoid. It is bounded on the sides by the turbinated bones, the superior maxillæ, and the ascending plates of the palatals. The septum is formed above by the very thin vertical plate of the ethmoid, which runs forward to rest against the beginning of the nasal bones. Septum. The under and posterior part of the septum is formed by the vomer, which runs from the body of the sphenoid to the back of the hard palate, and forward on it to the nasal crest of the upper jaw-bones. It is sometimes pretty solid, and is by far the strongest part of the septum. (Plates I. and II.) The angle left between these two plates is filled by the central cartilage which runs forward to the front of the nose, and the shape of the nose depends largely on its development, and on the degree of projection of the nasal bones.

The septum is very frequently, one might perhaps say usually, bent to one side, making one respiratory tract smaller than the other, and more liable to be occluded by congestion of the mucous membrane. (Plate II.) If the deviation be great enough to prevent respiration through one side, much greater inconvenience is occasioned than would be expected, but, owing probably to the elasticity of the cartilage, operations for its relief are uniformly unsuccessful. The nasal bones though small are very thick at their bases, which are interlocked. They give a very firm support to the top of the nose, but below they spread out into thin plates, to the edges of which the lateral cartilages are attached. At their upper part these are continuous with the median cartilage, but below they are separate from it. The median cartilage, after this separation, can be felt in the middle between these cartilages, and much more distinctly at the tip of the nose between the two scroll-like cartilages that form the alæ. Between these and the lateral cartilages are three or four insignificant cartilaginous nodules. The alæ are pretty freely movable, owing to small muscles that it is hardly worth while to describe, but it may be stated that they are supplied by the seventh nerve, and the movements of the alæ are consequently lost in facial paralysis. The nostrils look downward for the sake of protection against the entrance of foreign bodies, and their orifices are further guarded by small hairs. The bony plate that forms the floor of the nostrils forms also the roof of the mouth, and is inclined backward, thus carrying the secretions toward the pharynx. On front it rises into a median elevation, the anterior nasal spine, to which is attached the base of the septum. It is thicker in the median line than elsewhere, but it becomes regularly thinner from before backward. Behind, it ends in a median projection, the post nasal spine, from which the azygos uvulæ muscles run down

Cartilages.

into the soft palate which arises along its border. The sides of these cavities are thrown into folds by the turbinated bones, and between these folds are passages styled meatuses. When covered by mucous membrane they very much diminish the space in the cavity. The inferior meatus is overhung by the inferior turbinated bone, and is the chief respiratory canal. The nostril is above its floor, its entrance being guarded by a raised fold of skin. An instrument, therefore, must be pointed upward and immediately depressed to pass along the inferior meatus. Under cover of the inferior turbinated bone, at least one quarter of an inch from its apex, is the slit-like opening of the lachrymal canal. The middle turbinated bone does not reach so far forward as the lower, and perhaps a little farther back. Thus there is an open space left on each side under the bridge of the nose. If the middle turbinated bone is removed there is seen under it a curved fold bounding a groove which is convex anteriorly, and which ends on front in a small opening through which a probe may be passed upward into the frontal sinus. This is the infundibulum. (Plate I. 4.) The openings of antrum into the nose may be one or two in number. One always opens into this infundibulum, leaving the antrum just under its roof and consequently being quite incapable of draining it. (Plate II. 34.) This opening is sometimes single in the antrum and double in the infundibulum. There is also an occasional opening of the antrum lower down and farther back into the middle meatus.

Sides of nasal cavities.

Antrum has always an opening into infundibulum.

The superior spongy bone forms but a slight ridge in the posterior and upper part of the nares, below which is the upper meatus. Into this open, by a minute passage, the posterior ethmoidal cells (Plate II. 12), which are included in the posterior half of the upper lateral masses of the ethmoid. They are of varying size and number. They are internal to the orbit below the base of the skull, and on front of the sinus in the body of the sphenoid. They are separated by a constant partition from the anterior ethmoidal cells. Behind are the sinuses in the body of the sphenoid, which are separated by a partition invariably on one side of the middle. They lie under the sella turcica and extend on front of it. They open each by a small opening into the posterior part of the roof of the nasal fossæ. (Plate III. 19.) Thus we have the mucous membrane of the nose continued into the frontal sinus, the whole cavity of the upper jaw, the cells of the ethmoid and sphenoid. The mucous membrane completely covers the spheno-palatine foramen, so striking on the dried bone, which is just behind the superior meatus. The filaments of the olfactory nerve are distributed to the roof of the nares, to the two upper meatuses, and to the upper part of the septum; it is only on the latter that they reach the inferior meatus, so that the chief respiratory canal is happily nearly free from them. The vascular supply of the nares is important. In the infant, at least, the longitudinal sinus opens into them. The anterior palatine canal, or rather incisor canal, forms a *cul-de-sac* in the floor of the nose, and very rarely a canal.

Posterior ethmoidal cells.

Vessels of nose.

On the septum we have the artery which, together with the nerve, runs under the mucous membrane from the spheno-palatine foramen to the anterior palatine canal. Its course corresponds in general with the upper border of the vomer.

The cavities opening into the nasal chambers as described, are on each side, the nasal duct, the antrum, the frontal sinus, the anterior and posterior ethmoidal cells, and the sphenoidal sinus. They are all lined with mucous membrane continuous with that of the nose, but much less vascular and covered with ciliated epithelium. The membrane in the cavities contains glands which appear to be most numerous in the antrum; certainly it is there that they most frequently are recognized as the cause of trouble.

Communicating cavities.

The mucous membrane lining the nasal fossæ varies a good deal in different parts, but is everywhere thick and very vascular. In the space under the projecting nose, the epithelium is several cells deep with flattened cells at the surface, elsewhere it is columnar. There are ciliæ in the lower meatus and on the inferior turbinated bone, as well as on the lower part of the septum; in short, on the walls of the passage through which most of the air passes in respiration; but there are none in the parts above this in which the olfactory nerve is distributed. In the latter parts are peculiar cells supposed to be the terminal organs of the nerve. It has long been well known that the mucous membrane is very vascular and subject to sudden engorgements, but Professor Henry J. Bigelow[1] has the merit of having discovered the existence of a true erectile cavernous structure. The following extracts from his paper may be quoted without other comment than that, having seen his specimens, I entirely concur in his views. After stating that he has found "a remarkable and well-formed cavernous structure, at least upon the middle and inferior turbinated bones," Dr. Bigelow continues: "The difference in the size of the distended and collapsed cavernous bodies is quite strik-

Mucous membrane.

Dr. Henry J. Bigelow's discovery of true erectile structure on turbinated bones.

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[1] "Turbinated Corpora Cavernosa," *Boston Medical and Surgical Journal*, April 29, 1875. I am indebted to the kindness of Dr. Bigelow for the use of the following figures.

ing, and is best seen upon the inferior turbinated bone. Collapsed, the outline and dimensions are nearly those of its attenuated bony framework. Distended, it becomes an angry, turgid mass, of uneven surface and livid color, completely closing the lower nostril. A pouch-like dilatation projects from the rear of the bone, increasing its length, and with the aid of a blow-pipe readily showing on section, to the naked eye, cavernous cells. It is this reticulated pouch that is seen with the mirror at the back of the nares. Above it is seen the middle turbinated mass, similarly distended; and if the injection of the whole membrane is considerable, the nasal septum also swells to the thickness of nearly one quarter of an inch, especially near its posterior edge. (Fig. 6.) . . . . If inflated and dried, the cells project upon the surface. A section (Figs. 7 and 8) then gives further evidence of a cavernous structure, with closely juxtaposed cavities

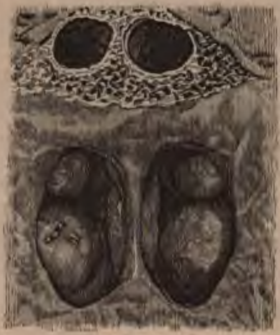

Fig. 6.

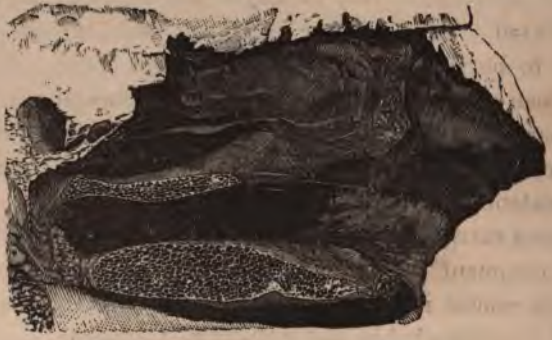

Fig. 7.

tolerably uniform in size and equally distributed; approaching quite nearly both the mucous surface and the bone. They communicate by irregular apertures, while minute bands and septa traverse and connect their common walls. A wet microscopic section (Fig. 9) exhibits

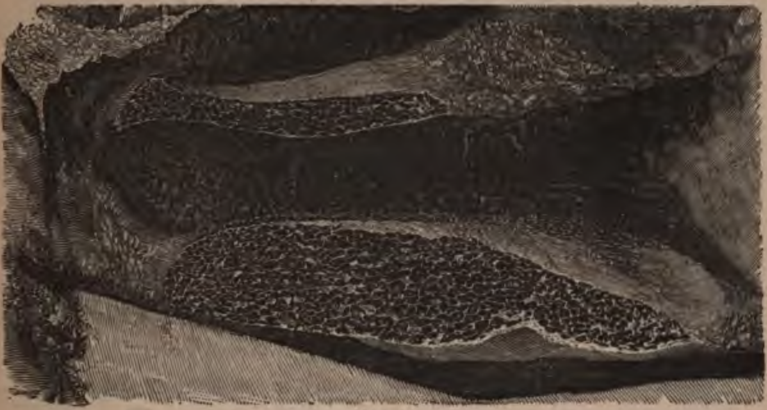

Fig. 8.

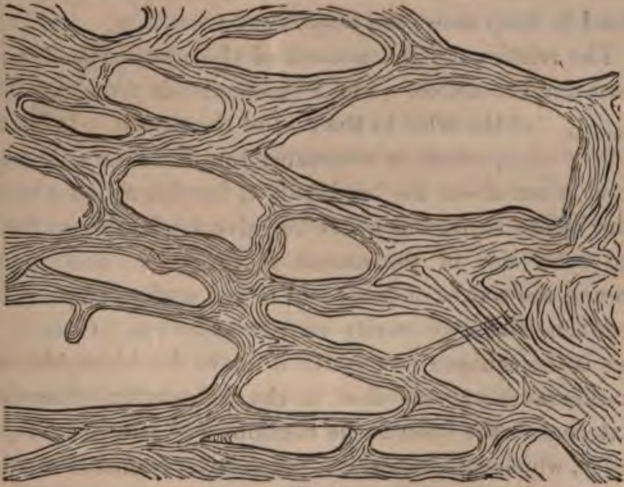

Fig. 9.

thin trabeculæ and walls, composed mainly of connective tissue, presenting cavities of unequal dimensions, and closely resembling the cavernous structure of the penis; although the smooth muscular element, as also the tunica albuginea of the latter, are somewhat more pronounced; as might be anticipated from the comparative erectile tension of this organ. . . . . Everybody is familiar with the firm and sudden impaction of the nose in acute catarrh; and has learned that a swallow of water, a pinch of snuff, a sudden start, mental or physical, as often clears the passage, to be again filled up." There has been more or less written about cavernous tissue and plexuses in these parts, the writer sometimes ending by quoting Kohlrausch, but his figures show that he did not demonstrate a true cavernous erectile tissue. The purpose of these structures, according to Humphry, who, however, did not grasp their anatomy, is to favor the moderate exudation of the watery constituents of the blood to keep moist the respiratory tract.

Relations of antrum.

The relations of the antrum of the upper jaw deserve some further notice. The former extends from the floor of the orbit to the roof of the mouth. It is very important to remember that the floor of the antrum is not above the hard palate, for this all goes to the floor of the nares, but above the alveolar border as far as the outer side of the canine tooth. The prominence around the socket of this tooth is just under the partition between the nasal cavity and the antrum. Outside of this is the canine fossa, which is above the bicuspids, and in the same verticle line is the infra-orbital foramen. External to the fossa is the beginning of the malar tuberosity, which sometimes, but not always, begins as a ridge thickening the wall of the antrum. Except at this point, and below, the walls are as thin as paper, and when the cavity is distended they become even thinner. The roots of the bicuspids and molars are implanted in the floor, and the removal of one of these may sometimes cause an opening without subsequent puncture. The inside of the cavity often presents ridges, both below and on the sides, which are caused by bone, but increased by folds of mucous membrane. The opening into the nasal cavity is high up from the floor. In the fœtus the antrum is merely a groove from the nose between the palate and the floor of the orbit, and develops by the separation of these plates. Its size is variable. I have examined a skull in which it was so small that the front wall of the maxilla, internal to the malar tuberosity, bounded the enlarged nasal cavity.

Vessels and nerves of antrum.

The arteries and nerves of the antrum are branches of the infra-orbitals. The nerve of that name is the direct continuation of the second division of the fifth pair which passes through the foramen rotundum, the spheno-maxillary fossa, and the fissure of that name, into the canal, usually an incomplete one, in the floor of the orbit. The artery which accompanies it in the canal is the end of the internal maxillary, which reaches the spheno-maxillary fossa by passing behind the antrum. The artery and nerve give off usually two dental branches, which respectively anastomose with one another above the roots of the teeth and which supply the lining of the antrum. The posterior artery and nerve usually send branches around the outside of the antrum.

Meckel's ganglion.

Meckel's ganglion is situated directly back of the antrum just below the apex of the orbit in the spheno-maxillary fossa. It is connected with the infra-orbital nerve by one or two twigs, but lies below it. Its chief branches are to the mucous membrane of the palate and nose. The two most important are the largest palatine branch which runs down the posterior palatine canal and the nerve of the septum that reaches the nasal cavity by boring through the membrane that closes the spheno-palatine foramen. This ganglion gives off, or more properly receives, the Vidian nerve that runs through the Vidian canal at the root of the pterygoid process at the rear of the fossa. This nerve consists of motor and sympathetic fibres. Behind the canal, these parts are distinct; the sympathetic join the carotid plexus, but the motor, under the name of the large superficial petrosal nerve, pierce the base of the skull through the closed middle lacerated foramen, and entering the hiatus Fallopii, join the facial at the geniculate ganglion inside the temporal bone. Thus the Vidian nerve may be said to contain the motor and sympathetic roots of Meckel's ganglion.

CHAPTER VIII.

THE MOUTH AND CHEEKS AND CHIN.

Lips.

THE entrance is formed by the lips, which are made up of circularly disposed muscular fibres, forming the orbicularis. (Plate I. 21.) They are covered on the outside by skin, and on the inside by mucous membrane, and the latter, though considerably modified, is continued externally, forming the red border of the lips that is seen when the mouth is closed. A vertical microscopic section through the lips shows the divisions very finely. The skin is characterized by the presence of hairs and sweat glands, the true mucous membrane by the numerous large mucous glands, and the intermediate portion by the absence of both. The fibres of the muscle are seen to run nearer to the surface at the junction of the skin and the intermediate part. There are a few muscular fibres running antero-posteriorly from the outside to the inside of the lip. The orbicularis becomes thin as it is removed from the lips, and is more or less interwoven with other facial muscles. Externally the fibres are joined by those of the buccinator. It is also attached to the bones, firmly above to the nasal spine and septum, and loosely below. The facial muscles raising and depressing the lips do not require description. They are supplied by the facial nerve. The skin of the lips is covered with hair, strong in the male, and but slightly developed in the female. The side of the cheek is formed by the buccinator (Plate II. 21), which mingles with the orbicularis outside of the corners of the mouth. It has sometimes been improperly classed among the muscles of mastication. Its action is to expel air from the mouth by blowing, and to assist the tongue in moving food in the mouth. It is closely connected with the mucous membrane, and perhaps one of its most important functions is to prevent this from falling in folds between the teeth during chewing and speaking. It arises under cover of the masseter from both the upper and lower jaw and from the so-called pterygo-maxillary ligament, which separates it from the superior constrictor of the pharynx. It is supplied by the facial nerve, and not by the long buccal branch of the third division of the fifth pair, as has been till lately supposed. The latter comes from that part of the third division which was held to be motor; nevertheless, it is sensory, and, piercing the muscle, goes to the mucous membrane. This has been established both by dissection and experiment, but an anomalous arrangement has been observed which is confirmatory; namely, Professor Turner, and others, have found this nerve arising from the second division of the fifth, which is undeniably sensory. On the outside of the buccinator, filling the angle between it and the anterior border of the masseter, is a pad of fat, which is crossed by Steno's duct from the parotid, which, piercing the buccinator quite obliquely, enters the mouth opposite the second upper molar. The buccinator is covered externally by a fairly defined fascia which goes backward over the constrictor. There is no distinct fascia under the skin of the greater part of the face, but a very variable amount of fat in which the vessels and nerves are imbedded. The blood for the superficial part of the face is derived chiefly from the facial artery, which crosses the border of the jaw at the anterior edge of the masseter, where it is

Buccinator.

Supplied by facial nerve.

Circulation of the face.

easily felt and compressed. It runs toward the inner angle of the eye, sending branches to the parts in front of its course. The coronaries are among the most important. They supply the lips, running near the red border, and meet their fellows from the opposite side. They very frequently are given off from a common trunk. Below the orbit there is a slight communication between the branches of the facial and those of the infra-orbital from the internal maxillary, and at the angle of the eye a more important one with the terminations of the ophthalmic from the internal carotid. It is also joined by the transverse facial from the temporal that crosses the face supplying the malar region. The facial vein starting at the orbit, where it is in free communication with the orbital veins, has the same general course as the artery, but is posterior to it and crosses the jaw near the angle. The skin of the face is very vascular, and is one of the places in which Suquet describes his "circulation derivative," that is, the passage of arteries into veins without intermediate capillaries, — a discovery that others have not been able to confirm. The nerves of the face are the terminal branches of the fifth pair that emerge from the three foramina, and have been repeatedly alluded to. The motor nerves, excepting those for the masseter and the levator palpebræ, come from the facial, which emerges from the front of the parotid. It should be borne in mind that the general direction of these nerves is forward. The smaller filaments of the fifth and seventh pairs unite very frequently, so that they are ultimately mixed nerves at their distribution. The facial also receives sensory fibres from the auriculo-temporal. The superficial lymphatics converge, for the most part, toward the angle of the jaw.

Capillaries between arteries and veins as elsewhere.

Nerves of face.

The mouth, strictly speaking, is not a cavity, and

Mouth filled by tongue.

becomes one only by muscular action. Normally it is filled by the tongue, with the possible exception of the very anterior part, where a slight space may exist. The boundaries are as follows: above the hard palate which forms an elongated dome descending on front and on the sides into the alveolar process for the teeth. It is continuous behind with the soft palate, which rests against the tongue. The great part of the floor of the mouth is formed by this organ, except on front and along the border of the lower jaw, where we have the floor of the mouth proper. On the sides, we have the double row of teeth, the alveolar process, and the front part of the inside of the ascending ramus of the lower jaw. That is, we have it to the point where the mucous membrane turns inward over the front of the internal pterygoid. The cavity (using the term loosely) of the mouth, is continued into the space between the lips and the teeth, which, it must be remembered, communicates even when the teeth are closed with the mouth proper around the back teeth.

Space between the cheek and alveolar process.

This space is of some surgical importance. The fold of mucous membrane from the lip to the gum is just below the opening of the nose. In the middle line there is a fold of mucous membrane from the anterior nasal spine and a trifling one on each side about over the anterior molar. The prominences and depressions of the upper jaw, treated of in connection with the antrum, can be very readily recognized. The malar prominence is very distinctly felt. It bounds the region that can be seen through the mouth without any incision; behind it the space between the cheek and the jaw runs up higher, and the finger can reach the apex of the coronoid process when the mouth is opened. Internal to the ascending ramus, and on the whole parallel to it, is a fold of mucous membrane that runs into the alveolar border, and may be mistaken (by the eye) for the ramus. It is formed by the border of the pterygo-maxillary ligament. An incision on the inside of the lower alveolar process just under and in front of the point at which this fold reaches the jaw, will reveal the gustatory nerve emerging from the internal pterygoid, just below the last molar. It may be divided, or indeed, a piece may be cut out in this place. The infra-orbital nerve emerges at the top of the canine fossa over the first bicuspid, or over the space between it and the next. The space beneath the lower lip is of less consequence. There is a very slight median fold of mucous membrane. The mental foramen, usually under the second bicuspid, is a little below the line of reflection of the mucous membrane.

Position of gustatory nerve in mouth.

Teeth.

The teeth of the upper jaw form a larger curve than those of the lower; this effect is particularly marked on front, owing to the forward inclination of the upper teeth, which overlap the lower. The canine teeth in both jaws mark the angle at which the front and lateral aspects unite. They are farther apart in the upper jaw than in the lower, owing to the greater breadth of all, but especially the two middle upper incisors; thus, the upper canines rest partly upon the lower ones and partly on the anterior bicuspids. The posterior teeth of the upper jaw turn somewhat outward, and those of the lower correspondingly, or indeed, more markedly, inward. The lower wisdom-tooth is usually inclined forward as well. The two rows of teeth end behind, pretty nearly opposite one another.

The roof of the mouth formed by the hard palate varies a good deal in breadth and in the amount of curve it presents. The bone is very rough for the firmer attachment of the mucous membrane. There is occasionally a small opening just in front, called the incisor canal, which may connect through passages in the anterior palatine canal with the nasal cavity. According to my observations, it usually is wanting, and it rarely is more than a very minute opening, though sometimes it is double and its orifices may be guarded by folds, as in Plate I. It represents a well-marked canal in some animals, but in man is of no kind of importance. It may be mentioned here that the anterior palatine canal contains also two others, more or less distinct passages for the nerves and arteries of the septum nasi, that pierce the palate, but as they are distributed under the mucous membrane, no trace of the openings can be seen during life. The folds alluded to are sometimes well marked, giving the front of the roof of the mouth the appearance of being strengthened by ribs. The hard palate ends behind in the posterior nasal spine in the middle, and on the sides it rests against the pterygoid plates. The hamular process of the inner one projects backward, and is easily felt through the soft palate. This is a muscular curtain lined on each side with mucous membrane; when at rest it lies against the back of the tongue and forming the front wall of the respiratory tract from the posterior nares nearly to the epiglottis; when in action it rises and forms the top of the alimentary tract, shutting the food out from the nose. The median prolongation known as the uvula lies in a corresponding groove on the back of the tongue, and the soft palate lies on that organ. Plate IV. shows how very near the uvula, even when of ordinary size, approaches the epiglottis. I have satisfied myself that these relations

Roof of mouth. Incisor canal.

Soft palate. Rests against tongue, forming front wall of pharynx.

are perfectly normal in the specimen from which the section was made, and bearing this in mind it is easy to see how much irritation may be caused by an elongated uvula.

On each side the soft palate may be said to be continued downward in two folds, the pillars of the fauces. The posterior, containing the palato-pharyngeus, runs down and backward into the pharynx; the anterior, containing the palato-glossus, into the tongue. The latter forms the lateral boundary between the mouth and pharynx. It will be more convenient to treat of the muscles forming the palate with the pharynx. The bony roof of the mouth presents just on front of the hamular process on each side, and internal to the last molar, or a little farther back, the posterior palatine canal transmitting the artery and nerve. The artery anastomoses with the anterior palatine, but its greatest surgical importance is that it is the chief vessel supplying blood to the soft palate, and that therefore it is desirable not to cut it in the operation for cleft palate. The mucous membrane of the mouth contains numerous compound glands which are named labial, buccal, and palatal, according to their position; two or three large ones constitute the molar group. They are situated around the inside of the mouth, inside the buccinator and on both the hard and soft palate.

Structure of tongue.

The tongue is an organ of a different plan from any in the body. It consists of muscles interwoven in such a way as to allow the most varied changes of form and, consequently, of position. The firmest point of origin is from the superior genial tubercles inside the symphysis of the lower jaw, and much of its substance springs from the hyoid; fibres enter it also from the stylo-glossus and palato-glossus.

Though the relations of individual muscles and bundles of fibres are very complicated, the general plan of the tongue is pretty simple. There is a median septum of loose fibrous tissue, and the muscular fibres are to be divided into three classes: 1st, a transverse set; 2d, some that may be called vertical, though in reality oblique; and 3d, longitudinal ones inclosing the others. The genio-glossi (Plate II. 26) that arise at the symphysis lie on each side of the septum, the anterior fibres run upward and forward to the tip, and the others more and more backward to the layer of fibrous tissue at the base of the epiglottis; as a rule, no fibres are inserted into the hyoid, and consequently the name of genio-hyo-glossus is incorrect. Outside of these muscles, and running forward and upward into the tongue, are the hyo-glossi (Plate II. 25), each of which has been divided into three parts according as it springs from the body, the greater or the lesser horn of the hyoid; but they are as well taken altogether. On the sides of the tongue these fibres take a longitudinal direction and some join the transverse group. The stylo-glossus divides as it enters into an upper and an inferior part, and each of these, though sending most of its fibres longitudinally along the tongue, sends some transversely inward. The palato-glossus runs superficially and longitudinally. The name lingualis has been applied by some authors to a group of longitudinal muscles on the top of the tongue, and by others to a group below; the name is of little consequence, provided it be understood that all the free part of the organ is ensheathed in longitudinal fibres. Near the tip there are vertical fibres running from the upper to the lower border. The transverse fibres which are interwoven with the ascending ones, spring mostly from the septum, which is not a partition through the whole of the tongue, but is rather a narrow strip broader behind than in front, which follows the curve of the dorsum, keeping about one third of an inch below it. It is by no means so well defined as some descriptions would imply. The transverse and vertical fibres as they approach the mucous membrane into which they are firmly inserted, leave spaces for the passage of the longitudinal ones. Microscopic sections show this arrangement very beautifully, and should be made in each of the three planes. They sometimes also show the individual fibres subdividing as they approach the mucous membrane. There is no submucous layer excepting far back. The various actions of raising, depressing, bending, and withdrawing the tongue can be understood by a study of the muscles, but the act of thrusting it out strikes me as hard to account for satisfactorily. Perhaps the best explanation is that the greater portion of the fibres of the genio-glossi, that is, all but those running into the very anterior part, by their contraction bring the mass of the tongue downward and forward, and that this pushes the tip before it. The muscular layers of the tongue are separated by loose connective tissue, often containing some fat which often sends prolongations among the smaller groups, especially in the course of vessels and nerves. The great tolerance of the tongue to the presence of foreign bodies which may have been driven into it is very remarkable. The mucous membrane covering the tongue varies greatly in the different parts; it is reflected from the tip and sides over the genio-glossi muscles to the floor of the mouth. The papillæ are not prominent except on the edges and upper surface, and present three well known kinds which need not be described minutely. The dorsum may be divided into three parts, a posterior one occupying the posterior half inch, or a little more, which

Movements of tongue.

Mucous membrane of tongue.

normally looks backward, is free from papillæ, and contains numerous glands as well as lymphoid follicles, though these may be wanting. On front of this comes the V of circumvalate papillæ, the apex of which is formed by the rather inconstant foramen cæcum (Plate IV. 35), which is the common opening of several glands. The distribution of the glosso-pharyngeal nerve ends in this region. The front part is covered with the filiform papillæ, among which the short, thick, red, fungiform ones are scattered. These latter are particularly numerous at the tip and edges. Two little glands, the lingual glands, are found near the tip of the tongue.

Nerves of tongue.

The nerves of the tongue are three: the glosso-pharyngeal, the gustatory from the fifth pair, and the hypoglossal. The last of these, the motor nerve of the tongue, runs in on the outer aspect of the hyo-glossus, which separates it from the lingual artery, which lies on the inner side of that muscle, between it and the genio-glossus. The course of the gustatory nerve at the side of the floor of the mouth has been mentioned. It runs forward for some distance at the side of the tongue and then breaking suddenly into many branches it spreads over the anterior two thirds. The posterior third is supplied by the glosso-pharyngeal, which, passing between the stylo-pharyngeus and stylo-glossus muscles, gives a branch to the tonsil and reaches the side of the base of the tongue. It supplies the mucous membrane as far forward as the circumvalate papillæ besides the sides of the pharynx. The shape and relations of the tongue when at rest deserve careful study. The results of frozen sections are instructive but not conclusive, as the state of the parts cannot be the same after death, especially in dissecting room subjects. I have satisfied myself from observations on the subject and study of the literature, that there can be no question that the tongue almost completely fills the mouth. The posterior part is vertical, and higher up presents a groove in which lies the uvula, as is seen in Plate IV. There is here some interspace as well as in Plate III., but it must be remembered that the mucous membrane of these parts during life, when full of blood, must be really thicker and more likely to adhere to a similar surface than after death. Judging by one's own feelings, it would seem that the tip of the tongue does not quite fill the anterior part of the mouth, but I cannot admit any approach to the space shown in Plate II. Mezger's and Donder's observations[1] show pretty conclusively that the mouth is kept closed during life by atmospheric pressure and not by muscular action. As Mezger states, if we open the mouth slightly and try to hold it so, the muscular effort soon becomes very fatiguing; and again, if keeping the lips closed we allow the jaw to drop slightly, the cheeks are pressed in by the outer air. This implies that the communication with the pharynx is habitually closed, but does not forbid the assumption that there may be some very slight free space in the mouth. The ease with which the tip of the tongue can be moved when the jaws and lips are closed would imply that there must be some free space around it. There is, however, very little inaccuracy in the statement that the tongue completely fills the mouth. The blood vessels will be considered presently with those of the floor of the mouth. The mucous membrane reflected from the tongue over the floor to the gums, forms in the middle line the so-called frænum linguæ, which is a fold running from the tongue to the lower jaw. It is often thought by fond mothers to be too short in their infants, and it can do no harm to divide it if it be remem-

Mouth kept closed by atmospheric pressure.

Frænum.

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[1] Pflüger's *Archiv*, 1875, p. 89.

bered that the chief veins of the tongue run under the mucous membrane of its lower surface on each side of the frænum. Just inside the symphysis and under the mucous membrane, on each side of the median line, lie the sublingual glands, which open by a dozen or more small ducts named after Rivini into the floor of the mouth. The glands extend backward for some distance, covered by the mucous membrane and resting on the mylo-hyoid muscle. On the under surface of the sublingual gland runs Wharton's duct, which, accompanied by a certain amount of glandular tissue, and surrounded by a plexus of veins, winds round the posterior border of the mylo-hyoid, and opens just below the free portion of the tongue close to the frænum. If the mucous membrane be carefully dissected up, or if a median section be made, a cavity known as the bursa sublingualis is found under the tip of the tongue and extending, according to Tillaux, as far as the first or second molar. It lies behind the sublingual glands and is partially subdivided by the frænum. It is lined with epithelium, and may be subdivided into many small chambers. It has been overlooked by many authors, but lately very well described by Tillaux. Under the genio-glossi are two muscles running from the symphysis to the hyoid bone, and serving to draw the latter forward, named the genio-hyoids. (See Plate II. 27.) Under this is the mylo-hyoid (29), which forms the real floor of the mouth and is called by Hermann Meyer, diaphragma oris. It arises from the mylo-hyoid ridge inside the lower jaw, from opposite the beginning of the alveolar process to the symphysis. The anterior fibres run obliquely inward to meet those of the other side in a median raphe of fibrous tissue. The more posterior ones run to the body of the hyoid. Some fibres

Sublingual glands.

Sublingual bursa.

Muscles of floor of mouth.

above these described run from one side of the mouth to the other. The two muscles, forming indeed but one, curve downward in the middle, and the action consequently is to raise the floor of the mouth, and it may be to pull the hyoid forward. The under or outer surface of the mylo-hyoid is covered by a distinct fascia, which sends prolongations round two muscles of much importance. These are the anterior bellies of the digastrics. (Plate II. 28.) Imagine that we are looking at the subject from the outside, and that the head is thrown far back as if to make room for an operation under the chin. We see above, the curve of the lower jaw, below and within it the hyoid, and the mylo-hyoid connecting them. Running on this from each side of the symphysis are the anterior bellies of the digastrics, which diverge from one another as they go toward the lesser horns of the hyoid to which the tendon between their anterior and posterior bellies is attached. They divide the supra-hyoid region into three; a middle one which is triangular, bounded behind by the body of the hyoid and on the sides by the anterior bellies which meet at the symphysis, and into two external ones between this muscle and the lower jaw. The space between the digastrics contains fat and some lymphatic glands and is shut in by another layer of fascia which runs off over the lateral region, and just inside and below the angle of the jaw is reflected round the submaxillary gland, which is inferior to the mylo-hyoid and sends Wharton's duct round its posterior border. The gland extends inward to lie on front of the greater horn of the hyoid and rests on the hyo-glossus muscle. There are many lymphatic glands in this region and inside the capsule of the gland, which they may conceal when enlarged. The gustatory nerve as it goes into the mouth lies on the gland just before crossing the

Submaxillary gland.

mylo-hyoid, and by it lies the minute submaxillary ganglion which receives its sensory fibres from the gustatory, its motor from the chorda tympani, which though in contact with the former nerve has not yet become intimately associated with it, and its sympathetic fibres from the facial plexus. It sends its branches to the sublingual gland and duct. The facial artery, as it passes from behind the jaw to get to the anterior border of the masseter where it crosses the jaw, runs under and often through the submaxillary gland. Outside of the fascia inclosing this gland there is found in the supra-hyoid region the platysma, which runs over the lateral parts to the face, then, especially in the middle, a layer of fat, and finally the skin. The lingual artery (Plate III. 35) has been left until now that its various relations might be taken at once. From its origin from the carotid it runs towards the hyoid bone and lies parallel to and just above the greater horn under cover of the hyoglossus. To tie it here, we have, beginning with a cut just above the greater horn, to cut down to the gland and turn it upward; we then see a triangle formed externally by the posterior belly of the digastric internally by the border of the mylo-hyoid and above by the hypoglossal nerve, which forms the base, the apex being below at the lesser horn. The floor of this triangle is formed by the hyo-glossus, which must be cut through to reach the artery. The triangle is usually said to be formed by the two bellies of the digastric and the nerve; but as the anterior belly is often somewhat internal to the border of the mylo-hyoid, this is the more accurate guide. As Guérin points out, this muscle cannot be mistaken for the hyo-glossus, if it be remembered that the nerve is on front of the latter and passes behind the former. It runs into the tongue between the

Submaxillary ganglion.

Triangle of lingual artery.

genio-glossus and the hyo-glossus, or sometimes in between the bundles of the latter. Before entering the tongue it gives off the sublingual branch wnich runs along the side of the floor of the mouth on the mylo-hyoid near Wharton's duct and which anastomoses by small twigs with the submental branch of the facial which runs below that muscle. The lingual artery sends off a branch which assends to the back of the tongue and as it runs to the tip is called the ravine. Hyrtl has proved that there is little or no communication in the tongue between the arteries of the two sides.

Veins of the tongue.

The veins of the tongue consist of four sets on each side: (*a*) the dorsal veins, that form a rich, submucous plexus on the back of the tongue above the larynx, communicating with the veins of the tonsil and pharynx, and opening into the internal jugular or some of its tributaries; (*b*) the two veins accompanying the lingual artery; (*c*) two with the gustatory nerve; and (*d*) two with the hypoglossal. Of these last the one below the nerve is the larger and more important. It has been called the ranine vein, and is seen on the lower surface of the tongue on each side of the frænum. It opens either into the facial or the internal jugular vein, and is of some surgical importance, as it crosses the little triangle in which the lingual artery is tied. The hyo-glossus lies between this vein and the artery. The veins that accompany the artery have several anastomoses with one another, and sometimes form an approach to a network around it. The different systems of veins in the tongue communicate freely with one another.[1]

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[1] Zuckerkandl, *Medizinische Jährbücher*, 1876.

CHAPTER IX.

THE REGION OF THE RAMUS OF THE JAW.

Joint of jaw.

To complete the description of the face there remains the region of the ascending ramus of the lower jaw and the zygomatic and pterygo-maxillary fossæ which are covered by it. The condyle is not placed transversely but slants backward and inward so that lines drawn through the axis of the two would meet at about the anterior border of the foramen magnum. Just behind the condyle is the tympanic plate forming the anterior wall of the ear, to guard which the zygoma sends downward a small process behind the jaw. On front of the glenoid cavity there is a strong transverse eminence which deepens the hollow and on which the the jaw moves. There is an inter-articular cartilage (Plate III. 22 and Plate IV. 24) between the glenoid cavity and the condyle which divides the joint into two. There is a strong external ligament with fibres directed backward and downward, which is but loosely attached to the fibro-cartilage, and is inserted just below the condyle. This may be said to suspend the jaw, and the axis on which the jaw revolves in opening runs through its insertion, so that when the mouth is opened the condyle advances on to the articular eminence and the angle passes backward and upward. As will be shown, however, this is probably not the whole story. The internal lateral ligament is double, consisting of a short and a long portion. The former, which has received hardly the attention it deserves, arises in common with the other from the spine of the sphenoid and the border of the glenoid cavity and is inserted into the inside of the neck at a point opposite the insertion of the external ligament. The long part of the internal ligament is a thin band that runs to the spine on front of the entrance to the dental canal. Besides these ligaments there is a capsule surrounding the two joints. The fresh joint presents a much narrower and deeper cavity than one would expect from the appearance of the skull. This is largely due to fibrous tissue on front of the tympanic plate. The bone forming the top of the glenoid cavity is thin and translucent. It has been broken by blows that drove the condyles against it. The temporal muscle has been described, with the exception of its insertion, which is into the tip, front, and back of the coronoid process and into the whole of its inner surface. It passes but slightly on to the outer aspect, but occasionally it may reach down far enough to meet the masseter. The ramus of the jaw is inclosed by two muscles having very similar attachments — the masseter (Plate III. 28) on the outside and the internal pterygoid on the inner. The direction of the fibres of the former is downward and backward, that of those of the latter is also outward. Judging from pictures and descriptions, one would think that there must be considerable diversity in the insertion of the masseter, and this is true, as may be seen by the varying size of the depression for it on the outer side of the ramus; a part of the variation, however, is due to that of the jaw. The superficial part running downward and backward is inserted into the ramus as high as the alveolar process. The deeper layer, distinct from the upper, is more vertical, and is inserted as high as the base of the coronoid process. The head of the lower jaw and the posterior part of the ramus are uncovered by

Insertion at temporal.

Masseter and pterygoids.

muscles. The internal pterygoid (Plate III. 24), which is inserted into the jaw as high as the dental canal, goes far to fill up the space between the ramus and the skull, excepting that taken up by the external pterygoid. There is, however, a good deal of space left between these muscles that is occupied by fat, in which lie numerous vessels and nerves. The masseteric fascia runs in on the back of this muscle, which forms the front part of the parotid space. The masseter closes the jaw, the internal pterygoid does the same, and also moves it laterally, that of each side drawing in the condyle at its own side, and thus throwing the condyle of the other side forward and outward and turning the chin to its own side. The external pterygoid (Plate III. 23) arises by two heads, one from the under surface of the great wing of the sphenoid, the other from the external pterygoid plate. These unite and run almost horizontally backward and somewhat outward to the head of the jaw, and also to the inter-articular fibro-cartilage, and thus take part in opening the jaw. If the jaw be kept shut the combined action of these muscles of both sides is to slide the under teeth in front of the upper. The forward direction of the fibres of the temporal, which is the chief closer of the jaw, is calculated to reverse this movement.

Action of muscles at jaw.

Thus it appears that, with the exception of the external pterygoid, all of these muscles close the jaw, and none of them open it, though that one assists in the act. If the mouth be kept closed by atmospheric pressure assisted by the adhesion of the mucous surfaces of the tongue and palate, it is clear that there is need of some muscle to open it, and it is self-evident that when it is opened widely strong muscular action takes place. I believe the most important muscle for this is the digastric, which arises under cover of the mastoid process from the base of the skull, is fastened by a loop of fascia to the hyoid, and then runs to the very front of the jaw. It is probable that the hyoid is fixed by the muscles inserted into it, and thus allows especially the anterior bellies of the digastrics and the genio-hyoids to draw the symphysis downward.

Internal maxillary artery.

The external carotid divides just behind the neck of the jaw into the temporal and internal maxillary arteries. The latter lies at first between the jaw and the long internal ligament, then in contact with the pterygoids, and passing, as a rule, between the heads of the external one, runs into the spheno-maxillary fossa. In the first part of its course it gives off the middle meningeal, which enters the foramen spinosum, a small meningeal for the foramen ovale, and the inferior dental that enters the dental canal after giving off the mylo-hyoid branch which runs below that muscle. The artery also sends the tympanic branch through the fissure of Glaser into the cavity of the tympanum. While in the fat of the pterygoid region the artery gives origin to the deep temporals, two or three in number, that run between the bone and the temporal muscle, and other branches to the muscles of the jaws and to the buccinator. In the deeper part of this region there is also a very rich plexus of veins called the pterygoid plexus, which communicates with the deep and superficial veins of the face, with those of the orbit, and, it may be, through the ophthalmo-meningeal, with those of the pia mater. The natural course of the blood in this plexus appears to be into the temporal vein.

The foramen ovale, through which passes the third division of the fifth pair of nerves, is situated internally to the origin of the external pterygoid. This division is

Third division of fifth pair of nerves.

Chorda tympani.

Entrance of dental canal.

composed of a motor and sensory root which unite as they pass through the foramen and immediately separate again after a slight interchange of fibres. The branch that is chiefly motor gives branches to the muscles of mastication, and one — the long buccal — which passes through the buccinator, to the mucous membrane of the mouth. The larger or chiefly sensory part divides into the auriculo-temporal, which arises by two roots inclosing the middle meningeal artery, passes behind the external pterygoid and the head of the jaw into the parotid gland, and thence to the side of the head, and into the inferior dental and gustatory (Plate III. 18), which have at first a similar course. They are at first, of course, on the inner side of the external pterygoid, and at its lower border they lie between the ramus and the internal pterygoid. The gustatory is on front, and gradually separates from the dental as it goes to the side of the mouth and tongue, as already described. This nerve is joined soon after its exit from the skull by the chorda tympani from the facial, which emerges from the fissure of Glaser and passes under cover of the condyle. The dental nerve runs to the canal in the inferior maxilla. The upper opening of this is about midway between the anterior and posterior borders of the ramus, and in a line with the tops of the teeth of the lower jaw, and often a little higher. The nerve may be resected here by trephining through the ramus, an operation which I believe was first performed by the late Dr. John C. Warren.[1] The gustatory nerve is at the level of the opening, so near the anterior border of the jaw that there is no danger of its being mistaken for the dental. The artery of this name is close to the nerve, at first lying deeper, and as they enter the canal, on front of it. The nerve like the artery has a mylo-hyoid branch to supply that muscle and the anterior belly of the digastric. Just behind the foramen spinosum is the otic or Arnold's ganglion which receives its sensory and motor roots from the third division of the fifth pair, and its sympathetic one from the fibres accompanying the middle meningeal artery. It is joined by the lesser superficial petrosal from the tympanic branch of the glosso-pharyngeal nerve, and sends branches to the tensor palati and tensor tympani muscles, — a suggestive arrangement which will be considered later.

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[1] *Boston Medical and Surgical Journal*, vol. i. 1828.

Otic ganglion.

CHAPTER X.

THE PHARYNX.

THE pharynx is the space situated on front of the vertebral column, under the base of the skull and behind the posterior nares, the soft palate, and the back of the tongue: it may or may not communicate with the mouth. It narrows below to open into the trachea and œsophagus. The posterior wall of the pharynx follows, of course, the curve of the spinal column, from which it is separated by the prevertebral muscles; but the upper angle between the atlas and the basilar process is rounded off as the superior constrictor is attached to a tubercle on the under surface of the latter some half inch on front of the foramen magnum. The views presented by Plates III. and IV. are exceedingly instructive. In the latter is the posterior wall and the mucous membrane lining it, which are cut in their oblique course. In Plate III. as well as in Fig. 6, we see the posterior openings of the nasal cavities, and under them the soft palate, which when the mouth is closed lies on the back of the tongue, the uvula filling a median depression on the back of the tongue just above the foramen cæcum; below this the front of the pharynx is formed by the back of the tongue which is uncovered by the soft palate. This is the portion free from papillæ, and is nearly vertical. In the view from behind it is hidden by the epiglottis. Below this is the larynx guarding the entrance to the windpipe, which may be described as a box in the lower part of the pharynx and on front of the direct continuation of

Relation of tongue to pharynx.

that cavity. It is easy to see how the falling back of the tongue upon the glottis during anæsthesia may produce suffocation. To take more in detail the different parts of the walls, we must begin with the posterior nares which are seen in Plate III. and still better in Fig. 6. It is opposite to them that the pharynx has its greatest antero-posterior diameter, for the soft palate lying on the back of the tongue extends backward as well as downward.

Opening of Eustachian tube.

On the side of the pharynx, in a line with the inferior meatus, and just back of the hard palate, there is the opening of the Eustachian tube guarded by a very prominent fold of mucous membrane which is usually horse-shoe shaped, with the opening below and with the stronger fold behind. In Plate III. (25) the cut has fallen on the right side just behind the opening, and consequently through the posterior fold and the very beginning of the canal. In fact, it is so close to the beginning as to be on front of the inferior wall, and it will be noticed that the canal is open below while on the left side of the plate it is closed.

Fossa of Rosenmüller.

Behind the posterior fold there is a pretty deep depression at the posterior superior angle of the pharynx called the fossa of Rosenmüller, which may be mistaken for the opening of the tube by the beginner in catheterization.

Eustachian tube.

Although outside of the pharynx, the Eustachian tube is to be described in this place, owing to the relations of the soft palate to muscles attached to it. It is a canal connecting the pharynx with the middle ear. It extends backward, outward, and upward from the posterior border of the internal pterygoid plate to the angle formed by the petrous and squamous portions of the temporal bone; and the walls of this part of its length — about three quarters — are cartilaginous. On entering the bone it runs backward and outward to the cavity of the tympanum. The cartilaginous part which occupies the inner side of the membranous part, shows great diversity of shape. The upper part, however, is turned over so as to bound the upper part of the outer side which is completed by membrane. As it goes backward the tube becomes smaller, and as it approaches the bone the canal is circular. After entering the bone it expands gradually into the tympanic cavity. It lies just outside of the carotid canal (Plate IV. 13), and above it is the canal for the tensor tympani muscle. As is seen in the plates, two muscles arise from it, and these are the levator and tensor palati respectively.

Relations of muscles to it.

The *levator palati* arises from the cartilage of the tube and from a small portion of the petrous bone, and extending downward and inward expands in the soft palate. The *tensor palati* (Plate III. 27) arises from the scaphoid fossa of the internal pterygoid plate and from the spine of the sphenoid and the edge of the tympanic plate, and from the outer side of the Eustachian tube between these points. The outer side, be it remembered, is the one which is completed by membrane. The muscle runs down between the internal pterygoid plate and the muscle of the same name and turns sharply inward under the hamular process. It spreads out in the upper part of the soft palate. This is the muscle that above all others tends to pull apart the flaps in cleft palate. It is very properly called tensor palati, but it deserves equally well its more modern name of *dilatator tutæ* as the act of swallowing opens the tube. This point has been made use of by otologists. It is possible with a little practice on one's self to open the tube and either to force air in or draw it out of the middle ear, as will be felt by the membranes of the drum being either driven out or drawn in. Such experiments, however, are not to be recommended. The otic ganglion gives nerves to this muscle and to the tensor tympani, which is the most important in regulating the tension of the drum; and this suggests that the otic ganglion may preside over what can be called the accommodation of the ear, just as the lenticular ganglion does over that of the eye. The Eustachian tube contains glands and is lined with ciliated epithelium. It is closed when the parts are at rest, but it is essential for good hearing that it should admit of being opened.

Muscles of palate.

The other muscles of the palate are the palato-pharyngei that run off down the posterior pillars of the fauces and the two improperly called azigos uvulæ on each side of the middle line. The soft palate may be divided into at least five layers; a central muscular layer, on each side of which is a submucous one containing many glands which are, however, most numerous below, and then two mucous membranes, of which the one toward the pharynx which is in continuation with the respiratory tract is covered with collumnar ciliated epithelium. The palate may be said, as already stated, to split at the sides into the anterior and posterior pillars of the fauces, and between these are the tonsils, situated very close to the tongue. It is to be regretted that they have not been struck by any of the sections. In that which is represented in Plate IV. the right one can readily be seen by drawing aside the posterior wall of the pharynx. They correspond pretty nearly to the angle of the jaw, and are separated from the internal carotid artery merely by the wall of the pharynx. The artery is a trifle posterior to the centre of the tonsil. It is supplied with blood not only by the tonsillar branch of the facial artery that enters its base, but also by neighboring twigs from the facial and ascending pharyngeal. When inflamed it is exceedingly vascular.

Position of tonsil.

When the mouth is closed we find the tongue appearing at the lower border of the soft palate. It forms a nearly vertical wall and is free from papillæ, very different from the anterior part of the organ. It is easy to see how, if it falls back, it will press the epiglottis across the larynx. The mucous membrane becomes thin as it passes from the tongue on to the front of the epiglottis, and it is thrown into three folds, one in the median line and one from each side of the epiglottis. These folds bound two depressions on front of the epiglottis in which foreign bodies are occasionally lodged. If we reckon the space in which the larynx is placed as belonging to the pharynx, we may say that at the level of the epiglottis it is bounded by the hyoid, which forms with its horns a semicircle on front. Under it and parallel with it are the wings of the thyroid cartilage, and inclosed by these, is the cricoid that forms the walls of the larynx.

Larynx.

The mucous membrane covering the cricoid covers also the arytenoid cartilages and those of Wrisberg, and then runs on to the sides of the epiglottis, making the boundary of the opening of the larynx. Between this fold and the thyroid cartilage is a depression, the pyriform fossa, in which foreign bodies should be looked for. Directly behind the cricoid cartilage is the end of the pharynx which passes into the œsophagus at its lower border. It is here very narrow; and as it is inclosed before and behind by unyielding walls, the cricoid and the vertebræ, this is the place where any large foreign body is likely to be arrested on its way to the stomach. The posterior wall of the pharynx presents nothing for description unless it be its relations to the subjacent parts. The upper angle is rounded off, as the tubercle to which the pharynx is attached is half an inch on front of the foramen magnum

Pharynx very narrow below.

and also as the basilar process is not horizontal, but oblique. A probe lying on the floor of the nares strikes the atlas, and it is the long body of the axis that is opposite the back of the soft palate. The succeeding vertebræ are less deep and the lower border of the sixth is opposite the beginning of the œsophagus.

Constrictors

The walls of the pharnyx are formed by the three constrictors, the fibres of which have, on the whole, a transverse direction, and by longitudinal fibres of the palato-pharyngeus muscle, some from the Eustachian tube, and of the stylo-pharyngeus that enters the pharynx between the superior and middle constrictors. The constrictor muscles overlap one another from below upward; thus the highest passes under the middle one and that under the lowest. The origin of the highest corresponds in general with that of the buccinator, the two meeting at the pterygo-maxillary ligament. This constrictor arises also from the tongue, the back of the mylo-hyoid ridge of the lower jaw, and the lower third of the internal pterygoid plate. The Eustachian tube passes over its side and the tensor palati is outside of it. The most peculiar is the middle constrictor, which, together with its fellow, has the shape of a diamond; arising by two of its points from the hyoid, it reaches by its upper nearly or quite to the basilar process, and by its lower nearly to the œsophagus. The mucous membrane contains many glands and lymphoid follicles. Outside of the muscular coat is a layer of connective tissue that may pass as a fascia, and this is connected with loose areolar tissue between the pharynx and the prevertebral fascia that covers the muscles. This allows free motion of the walls and at the same time affords them some support. The mucous membrane is said to be supplied by the glosso-pharyngeal nerve, and the

Mucous membrane.

muscles mostly by the pharyngeal branch of the pneumo gastric; but these nerves and the sympathetic are in the freest inter-communication. According to Jacob of Munich,[1] they form two plexuses, an intermuscular and a submucous, precisely analagous to those of Auerbach and Meissner in the intestines. The relations of the important vessels and nerves on the side of the pharynx, must be taken as a part of the following chapter.

[1] Virchow and Hirsch, *Jahresbericht*, 1873.

CHAPTER XI.

PAROTID AND SUBPAROTID REGION.

Let the reader now look at or imagine a skull with the spinal column attached, and then imagine it covered by the soft parts that have been described up to this point. If he does so, he will see the skull, the face, and the pharynx, the latter filling the interval between the face and the spinal column, but all the soft parts back of the ramus of the jaw will be wanting, and the cavity between the jaws, the mastoid process, the base of the skull and internally the pharynx, will be especially striking. The entrance to this space from the side is triangular on the skull, or rather it is between two lines that meet above. The anterior is the back of the jaw, the posterior the front of the meatus and lower down the mastoid process. Somewhat deeper and lower than this is the lateral mass of the atlas (Plate V. 20), which can be felt during life. Running into this space is the styloid process (Plate IV. 38), which is of importance in dividing it into two regions, a superficial and a deep. This space is much diminished when the muscles are in place. The thick sterno-mastoid runs up to the mastoid process, passing just behind the angle of the jaw when the head is in the natural position. The digastric arises from the digastric groove under the mastoid process, and lies under that muscle till it passes under the angle of the jaw and is attached by its central tendon to the lesser horn of the hyoid. The styloid process has three muscles arising from it, of which the stylo-hyoid

Relations of styloid process and its muscles.

is the most superficial. It is just on front of the posterior belly of the digastric till the latter passes through it near the hyoid. (Plate IV. 28 and 29.) The stylo-glossus runs forward to the tongue and has nothing to do with the space we are now considering. The stylo-pharyngeus runs inward to the pharynx. From the styloid process comes also the membrane known as the stylo-maxillary ligament, that runs to the back of the jaw, joining the fascia that covers the hinder surface of the internal pterygoid, and is continuous with the masseteric. The cavity between these muscles may be called pyramidal. The base is at the skin and the apex at the styloid process. It contains the parotid gland, and is of great surgical importance. The general arrangement of the fasciæ has been described, but some additional details are wanting. The fascia of the neck which incloses the sterno-mastoid, splits on front of it to form the capsule of the gland.

Fascia.

This splitting, however, does not take place immediately at the border of the sterno-mastoid, but a little on front of it, so that it is possible, when the head is thrown back and the face turned away, to dissect in deeply behind the gland. The capsule of the gland sends in numerous fibrous partitions that subdivide it into small lobes. The gland extends inward against the styloid muscles and fascia forward, to the internal pterygoid, and upward to the back of the neck of the jaw, the cartilaginous, and a little of the bony meatus. The gland sends off two prolongations, a deep and a superficial. The

Prolongations of parotid.

former, passing through an opening in the fascia on front of the styloid process, extends inward to the pharynx and goes forward under the internal pterygoid. (Plate III.) This prolongation and the relations of large blood vessels makes the extirpation of the entire gland an impossibility. The superficial prolongation is a certain amount of glandular tissue that accompanies the duct on to the cheek over the masseter. This has been called the socia parotidis. Steno's duct runs in a line from opposite the lower border of the lobe of the ear to midway between the nose and the lip. The former of these points is, of course, rather variable, but the line given is sufficiently accurate: a branch of the facial accompanies the duct. When the latter reaches the border of the masseter, it turns over a very constant deposit of fat which lies on front of that muscle and then pierces the buccinator obliquely opposite the second bicuspid of the upper jaw. Concerning the parotid it remains to be said that, besides this prolongation, the gland itself overlaps more or less of the masseter above the angle of the jaw, and also that the lower part of the sheath that separates it from the sub-maxillary region is very well marked.

Course of Steno's duct.

The capsule of the parotid contains not only the glandular tissue but also vessels and nerves of very great importance as well as some lymphatic glands; but to obtain a connected idea of these structures, we must take at once the space below the gland in the neck and also that between it and the pharynx. At the level of the top of the thyroid, or often a little higher, the common carotid divides into its two branches. Below that point the artery, internal jugular, and pneumogastric are in a so-called sheath, namely an accumulation of areolar tissue surrounding the vessels and nerves and passing between them. This state of things continues around the internal carotid, the external going alone. At the point of bifurcation the internal carotid lies outside, and behind its fellow, but almost immediately it changes its course and runs more deeply inward. It goes up with the vein and nerve (Plates IV. and V.) under the paro-

Internal carotid.

tid gland, the styloid muscles, and the styloid process that help to form the parotid chamber, to the base of the skull. It lies close against the walls of the pharynx, and, as stated elsewhere, just external to the posterior part of the tonsil. The artery is on front of the vein, and goes into the carotid canal; just behind and inside of this is the nervous part of the posterior lacerated foramen through which pass the pneumogastric with the spinal accessory close behind and the glosso-pharyngeal a little in front of it. Behind both this and the carotid canal, and it may be extending decidedly outside of it, is the jugular foramen and fossa, which when large contains the expanded beginning of the vein. When the parotid has been removed, a little dissection shows the stylo-pharyngeus muscle from the root of the styloid process running downward and inward to the pharynx like a curtain, and dividing the deep space into a posterior one between it and the prevertebral muscles which contains the important vessels and nerves, and an anterior one between it and the pterygoids of less consequence. The glosso-pharyngeal nerve runs forward between the internal carotid and the vein to the outer side of the stylo-pharyngeus to the side of the pharynx. It gives off the tympanic branch (Jacobson's nerve) that enters the very constant but minute canal on the ridge in the temporal bone that separates the carotid and jugular openings. It joins the facial nerve at the geniculate ganglion and also the sympathetic and the large superficial petrosal from the spheno-palatine ganglion. The pneumogastric keeps between the vein and artery, giving off an auricular, a pharyngeal branch going to form the plexuses already mentioned, and the superior larnygeal which runs towards the larynx under the internal carotid. The spinal accessory nerve consists of two parts, the accessory

Nerves.

which joins the ganglion of the root of the pneumogastric and the muscular branch that passes, backward usually, under the jugular vein and then turns outward to go through the sterno-mastoid into the trapezius. These nerves, together with the sympathetic, form many complicated anastomoses at the base of the skull, but the arrangement is so complex and the physiology so unsatisfactory that it is not worth while to enter on the question in a work of this kind. Besides these nerves, there are the facial and hypoglossal that must be spoken of in this connection. The former, emerging from the stylo-mastoid foramen, sends off branches to the posterior belly of the digastric and the stylo-hyoid, and the posterior auricular which supplies the little retractor of the ear and the posterior belly of the occipito-frontalis. The nerve almost immediately after its exit plunges into the parotid, which it strikes in the posterior part of its inner surface, and runs horizontally forward in it, becoming more superficial as it goes on. Inside the gland it divides into many branches, which are assembled into a temporo-facial and a cervico-facial group, and these emerge from the front of the gland. Division of this nerve of course causes a very general facial paralysis. It is joined in the substance of the gland by the auriculo-temporal of the third division of the fifth pair.

Facial nerve.

Hypoglossal.

The anterior condyloid foramen, through which passes the twelfth pair, the hypoglossal, is internal to and not much behind the nervous part of the jugular foramen. The nerve is united by connective tissue and by some fibres to the pneumogastric, around which it turns. It then runs outward between the artery and vein, and descends toward the neck on the inner surface of the digastric and stylo-hyoid behind the parotid. Leaving it there, we will now return to the external carotid at its origin. It runs more directly upward than the sterno-mastoid, and consequently is free from its anterior border. The position of the head is of great importance, changing its relations just as the position of the arm changes those of the axillary artery. When the space behind the jaw is made as large as possible, it is quite free from the sterno-mastoid; when the jaw is drawn down, the artery is under cover of its angle. The branches of the external carotid are given off in rapid succession, and usually all of them except the two terminal ones and the posterior auricular before entering the gland. The lingual and the facial are both directed downward, and are tortuous in order to be able to share in the movements of the parts without danger. These branches all anastomose freely with one another, and consequently it is not rare to find one smaller than usual and the neighboring one correspondingly enlarged. The external carotid enters the parotid gland, but as Tillaux[1] claims, and I believe with justice, no accurate details have been given by any one before him. He is certainly correct in stating that the artery does not enter the gland from below, but on the inner side at a point which is variable. He places it usually opposite the junction of the lower and middle third of the ramus of the jaw. As it ascends, the vessel becomes more superficial, and just behind the neck of the jaw it divides into the temporal and internal maxillary arteries, which, with their veins, make this a dangerous place. The posterior auricular arises in the gland, and the occipital before the carotid enters it about opposite the facial artery. The occipital is of importance as the hypoglossal nerve, passing from under cover of the digastric, turns forward under it

External carotid.

Its relations to parotid.

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[1] *Traité d'Anatomie Topographique,* 1875.

Veins.

and crosses the carotid, giving off as it does so to the descending branch. The parotid is well supplied with veins, which in disease of the gland become, as is usual, much enlarged. Their arrangement is uncertain. The external carotid has no true companion vein, but a temporal vein passes through the gland, somewhat superficial to it, behind the ramus, receiving the veins from the side of the head, the internal maxillary from the pterygoid plexus, and other deep veins. After leaving the gland, but sometimes before, the vein divides into two branches, one of which runs back from behind the angle of the jaw over the sterno-mastoid, and receiving the posterior temporal and others, becomes the external jugular vein, while the other branch opens into the facial, and with it carries its blood to the internal jugular. The facial vein leaves the face at the angle of the jaw, and in spite of variations one may be very sure of of finding a large venous branch at this place, running to the internal jugular. Before leaving this region a word should be said of the lymphatic glands. There is a chain of deep ones along the internal jugular vein extending from the base of the skull down the neck, and it is important to know that there are a few not only over and under the parotid but in its interior.

CHAPTER XII.

THE EXTERNAL EAR.

THE outer ear (pinna), which is said to collect the waves of sound, is probably of little practical value in the human species. It is made of elastic cartilage, areolar tissue, and skin. Much might be said of the diversity of form it presents but it is sufficient here to give the names of its more marked folds. The narrow one that bounds the upper and posterior edge is the helix, and the less distinct one inside of and in part parallel to it is the anti-helix. The short but very distinct prominence at the attached border just on front of the canal is the tragus, which is separated by a notch from the anti-tragus behind. Just under the notch is the lobe. The walls of the general cavity that leads into the meatus constitute the concha. The greater part of the ear is cartilaginous and the skin is closely adherent to it. It is least so on the posterior surface of the concha. The lobe contains no cartilage whatever, and thus earrings may work their way through it slowly or be torn through without great violence.

The ear is attached by ligaments to the root of the zygoma and mastoid process. The superior and anterior muscles of the ear have been alluded to in connection with the soft parts of the side of the head. The posterior is deeper, arising from the mastoid process instead of the aponeurosis, and is easily found, which is more than can be said of the others. The muscles of the pinna itself are quite unworthy of description. The external meatus is the passage from the concha to the middle ear, from which it is separated by the membrane of the tympanum. It varies in length from an inch to an inch and a quarter and runs forward and inward. It is formed at first by cartilage, and for nearly two thirds of its length by bone. Its roof, indeed, is entirely of bone, for it begins directly under the zygoma, which is more prominent than the lower part of the auditory process, and the cartilage does not form a complete tube but is wanting on top. The cartilage may be subdivided as is seen on the left of Plate IV. The same plate shows that at first the canal rises decidedly; at about two thirds of the way it bends downward, and the point where this change takes place is the narrowest in the canal. The beginning of the canal is oval, the greatest diameter being nearly vertical, and it is customary to say that at the inner end it is transverse; the canal at this point, however, is about circular. The entrance is guarded by the tragus and by hairs around its orifice which tend to arrest foreign bodies. The skin is continued at first along the cartilage, and then along the bone, where it is intimately united with the periosteum, and finally it covers the membrane of the drum. If by catarrh we understand an inflammation of a mucous membrane, it is evident from the above that it is an error to speak of a catarrh of the external meatus. Sebaceous glands are found in the pinna and in the meatus, but the characteristic glands of the latter are the cerumenous ones found in the cartilaginous portion. In structure they are very like sweat glands.

External meatus.

The membrane of the tympanum is inserted into a groove at the inner end of the canal, except at the upper border. It is placed very obliquely

Membrana tympani.

to the axis of the meatus, being nearly parallel with the median vertical plane of the head, thus forming an obtuse angle with the posterior wall of the meatus and an acute angle with the anterior one. It is also inclined laterally, so that its lower border is more deeply situated than the upper. It is probable that this position of the tympanum is for its better protection against sudden loud noises that would affect it more violently if it were at a right angle to the axis of the meatus. The membrane consists externally of skin, internally of the mucous membrane of the middle ear, and between these structures of fibrous tissue. The fibres for the most part radiate from the centre, but under these there are circular ones which are best seen at the periphery. The handle of the malleus, one of the little bones of the middle ear, lies in the substance of the membrane in a little bed of fibro-cartilage discovered by Gruber of Vienna. It runs downward and a little backward, and is easily distinguished when the ear is examined with the speculum. The relations of the external meatus are of interest. Above, the lower wall of the skull (Plate IV.) is pretty thick up to the point of the insertion of the tympanum. The front wall, formed by the tympanic plate, is thin except near the junction of the cartilaginous part, and might be broken by blows on the jaw. Behind are the cells of the mastoid process separated from the meatus by a thin plate of bone.

CHAPTER XIII.

THE SPINE AND OCCIPITAL REGION.

THE spine is separated from the cavity of the pharynx by the prevertebral muscles and fascia and a certain amount of connective tissue under the latter. This tissue is most abundant at the upper part. Relations of atlas. The atlas is behind the upper part of the nasal cavity, and under it is the long body of the axis which reaches to about the level of the uvula when it is resting against the back of the tongue; but when the mouth is opened and the soft palate raised, the axis can be felt through the mouth; the third vertebra also and still others can be so reached. The lateral masses of the atlas are very prominent and are easily felt lower and deeper than the mastoid process, by pressing firmly inward on the sterno-mastoid muscle. The point that is felt remains stationary when the head is bent and turns when it is rotated. The lateral masses of the axis are shorter. Vertebral artery. The vertebral artery, which runs through the transverse foramina, has to turn outward as it passes from the axis to the atlas, and having passed through the foramen in the latter bone, winds backward and inward in the groove round the articular processes and then pierces the dura mater. The groove in which it lies is frequently bridged over by one or more pieces of bone which may unite to form the roof of a canal. The vertebral vein or veins that pass through the foramina with the artery, take their origin on the outside of the skull, though they have communications with the cranial and spinal cavities.

The head, which rests by its condyles in the articular cups of the atlas, is not perfectly balanced, but has a tendency to drop forward, which is counteracted by the strong muscles of the back of the neck assisted by the slight elastic power of the ligamentum nuchæ. The space between the front parts of the lateral masses of the atlas and its anterior arch, is filled by the odontoid process of the axis, which is held in by the transverse ligament of the atlas which springs from a tubercle inside the lateral masses. It is not straight but much curved, as may be inferred from Plate V., where its origin on each side of the odontoid is seen, but where the middle, going behind the odontoid, is cut off. This transverse ligament is sometimes called the crucial, owing to two processes which it gives off behind the odontoid, the upper of which goes to the occiput, and the lower to the body of the axis. The front and back of the odontoid process have each a cartilaginous surface for a synovial bursa. The anterior one spreads for some distance around the odontoid, and sometimes communicates with the joints between the atlas and occiput. As is seen in Plate V., the odontoid projects up above the level of the atlas, to that of the anterior border of the foramen magnum, or very near it, and thus is between the condyles of the head. The very strong check ligaments which go from the top of the odontoid to the inside of the condyles, pass but very little upward. It is to be noticed that some of their fibres meet behind the odontoid with those of the other side. These ligaments, as well as the transverse ligament, are very powerful, and keep the odontoid in the small space that is devoted to it. The joint between the odontoid and the atlas is a purely

Odontoid process.

Transverse ligament.

Check ligaments.

rotary one, the head and atlas turning on the odontoid and the articular surfaces of the lateral masses of the atlas and axis sliding on one another. These plates are inclined downward, outward, and backward, and when covered with cartilage are nearly flat, so that this sliding movement, which, of course, is essential to the rotation of the atlas, may take place. The amount of motion in this joint is estimated at only 60°, so that in actions requiring greater movement of the head other joints of the spine are called into play. The check ligaments received their name from a correct appreciation of their office in limiting rotation. Flexion takes place between the atlas and occiput, and it is possible that when one condyle is made a fixed point, the other may perform some slight oblique rotation. It is evident that the protection against dislocation of the odontoid is very perfect, and in executions by hanging there is far more likely to be fracture of the axis, or dislocation with or without fracture between the second and the third vertebræ. As a rule, however, there is no injury to the spine, and the common statement, "the neck was instantly broken," rests on the newspaper reporters' preconceived ideas. The arches of the cervical vertebræ are narrow, and their spinous processes short, that they may not interfere with extension, that is, throwing the head back. The spinous process of the axis is somewhat of an exception, as it needs to be rather long and strong for some muscles that arise from it. The result of this is that when the head and neck are bent the spinal canal is but imperfectly protected. The great mass of muscles that fill the space between the base of the skull as high as the superior curved line of the occiput and the spine demands no detailed description. Under the skin and subcutaneous fascia is the fascia that incloses the trapezius, and going

Spine rarely injured by hanging.

outward becomes the fascia of the neck. The trapezii being removed, we see a triangular space, subdivided by the ligamentum nuchæ, filled by the fibres of the complexi passing up to be inserted between the two occipital lines. The boundaries of this triangle are the splenii lying on the complexi, and diverging from one another to their terminations in the mastoid process and outer part of the upper line under cover of the sterno-mastoid. The splenii (capitis) have much to do with moving the head, and may act either as antagonists or associates with the sterno-mastoids. If the two latter act together they bend the head forward; if the two former they throw it back; or the sterno-mastoid of the right side will be assisted by the splenius of the left in turning the face to the left, and while it assists in the turning it will oppose the bending downward that the action of the sterno-mastoid alone would produce. Under these is a group of four short muscles acting on the head and axis; they are the two straight and the two oblique muscles. The two largest and most important are the greater straight and the inferior oblique one. Both arise from the spinous process of the axis, the former going (in spite of its name) obliquely outward to the inferior curved line, and the latter to the transverse process of the axis. This one is consequently a rotator of the head. The points of insertion of these two muscles are connected by the superior oblique, and thus a very well defined triangle is formed on each side, in which is seen the arch of the atlas, with the vertebral artery, and from which emerges the posterior branch of the sub-occipital nerve. Though very plain it must be confessed that the triangle is of little surgical value. The great occipital from the second cervical nerve appears below the inferior oblique to make its way to the surface.

Muscles of back of neck.

Action of splenii.

Short muscles of back of neck.

CHAPTER XIV.

THE CIRCULATION.

THE intra-cranial circulation requires a separate chapter, while but a few words in addition to what is said elsewhere, will be sufficient for that of the outside of the head. This is supplied wholly by the branches of the external carotid, with the exception of the frontal region, where those of the internal carotid reappear. The lingual, internal maxillary, and ascending pharyngeal are deeply situated, and the others, with some exceptions, run superficially. There is a very free system of anastomoses between the various branches and between the deep and the superficial ones. There are, however, but few communications of importance between the opposite sides. As a result of this freedom of union, we have the great danger of recurrent hemorrhage after wounds of the vessels, which can be certainly averted solely by the ligature of both ends of a cut artery. The veins are large and numerous, but it will be sufficient here to refer to the many small branches uniting the tributaries of the external and internal jugulars, and especially to the large communicating branch near the angle of the jaw.

Freedom of anastomosis between arteries of head.

The circulation inside the skull, though governed by the same laws as elsewhere, is modified in various ways by the peculiar surroundings. The adult skull is practically a closed case, as the openings are completely filled by the vessels and nerves

Adult skull practically a closed case.

passing through them, assisted in some cases by cartilage, and everywhere by the firm and tense dura mater. The brain is well-nigh incompressible, and for these reasons it has been argued that the amount of blood in the skull could not vary; a conclusion which is absolutely unfounded. If instead of *blood* we read *fluid* the conclusion is very nearly accurate. I say *very nearly*, for it is not impossible that some slight variation in the size of the brain may take place. Those who have upheld the former theory did not appreciate the importance of the cerebro-spinal fluid, which by its free passage from and into the spinal canal, and the rapidity with which it may be secreted, is able to maintain the plenitude of the cranium. For physiological and pathological reasons the distribution of the arteries deserves careful attention. The carotid and vertebral arteries are strongly bent just before they enter the cavity of the skull, to break the force of their pulsations that otherwise might be injurious to the brain. The carotid and the internal jugular vein, which are close neighbors in the neck, diverge as they pass through the skull. It has been suggested that as the blood in them flows in opposite directions, the pulsations of the artery might interfere with the escape of the blood through the vein, if the vessels lay in a common canal. The vertebral arteries (Plate V. 14 and 24), after perforating the dura mater, run forward outside the hypoglossal nerves which cross over them, to meet and form the basilar at the beginning of the pons Varolii; they first, however, give off the spinal arteries that run down the canal, and the posterior inferior cerebellar arteries (Plate VI. 8) which enter the sides of the fourth ventricle over the restiform bodies, and continuing backward between the vermiform process and the lateral lobes of the cerebellum, supply

Arteries of cranial cavity tortuous on entering.

Basilar artery.

the under surface of that organ. The basilar artery does not equal in calibre the combined size of the vertebral arteries. It sometimes has a median ridge on its inside, which is the remains of the walls which separated the two vessels that originally were in its place. This hint serves to explain the occasion of an anomaly that I am inclined to think is not very rare; namely, when the basilar is formed entirely by one vertebral artery, and the other, which is throughout much the smaller, ends at a varying distance from its normal termination. The basilar gives off small branches to the pons and the anterior inferior cerebellar artery which is smaller than the inferior one. At the front of the pons it divides into the two posterior cerebral arteries that pass off at right angles with its course, and just before this gives off the superior cerebellar arteries which ramify under the tentorium. The curves and course of the carotid have been described up to the point where it leaves the cavernous sinus by the side of the sella turcica and piercing the dura mater by the anterior clinoid process, curves backward before dividing into its terminal branches, the anterior and middle cerebrals. Just after perforating the dura mater, it sends from its anterior convexity the ophthalmic artery through the optic foramen. The anterior cerebral arteries run forward and inward across the anterior perforated space to the median fissure into which they pass, and ultimately run backward over the corpus callosum. As these vessels reach the beginning of the median fissure they are connected by the little anterior communicating artery, which is hardly longer than it is thick. The middle cerebrals, which are the direct continuations of the carotids, run outward into the Silvian fissure. From their position they are partic-

Branches of internal carotid.

ularly liable to receive an embolus that is carried up through the carotid artery. There are two small branches, the posterior communicating, that run from the posterior cerebrals to the carotids, just before their final subdivision. These make the sides of the celebrated circle, or, as the purists will have it, the polygon of Willis. This is formed by the posterior cerebrals, the posterior communicating, the carotid, the anterior cerebrals, and the anterior communicating. This arrangement appears admirably adapted to secure a supply of blood to all parts of the brain after occlusion of any of the main trunks, as for instance, after ligature of one or both carotids; but after a clot has passed the circle its usefulness is at an end, owing to the few and trifling anastomoses between its branches. An anomalous arrangement, which seems better than the normal one, is not very rare. It consists in the posterior communicating opening into the middle cerebral instead of into the carotid. Thus, if a clot should be arrested at the bifurcation of the carotid into the anterior and middle cerebrals, the latter important vessel would lose its supply of blood if the arrangement should be normal; but if this variation occurred, the posterior communicating might carry a stream of blood into the middle cerebral beyond the obstruction. It should, however, be borne in mind that the posterior communicating arteries are often of very minute calibre, and there seems reason to doubt whether the circle of Willis is so admirable a system of anastomoses as one at first supposes. Lefort [1] has found that of two hundred and forty-one cases of ligature of the carotid, seventy-five, or nearly one third, were followed by more or less severe cerebral disturbance. The circulation of the brain has lately been very carefully studied by Duret,[2] who has

Circle of Willis.

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[1] *Bulletin de la Société de Chirurgie de Paris*, tome IV.

[2] *Archives de Physiologie*, 1874.

corrected some generally received errors, and has worked out with great precision the supply of the different parts. One of the most striking, and to me incomprehensible, arrangements which he has made out is the almost absolute absence of anastomoses.

Duret's investigations of the cerebral circulation.

He dwells on the scarcity of communications of the branches of the carotids with each other and with those of the opposite side, and states that the branches of the vertebrals anastomose freely. The arteries of the corpora striata are divided into an external and an internal group, and come from the middle cerebral, excepting a few inconstant ones from the anterior. Their course, at first, is upward and outward, after which they turn forward, forming externally convex curves. They have no anastomoses with other arteries, nor with each other, and end in small "brushes" of branches. The arteries of the optic thalami are similarly arranged, and come from the posterior cerebral, the posterior communicating, and the choroid arteries. The terminal branches of the arteries of the convolutions may be divided into two sets, those of the pia mater and those entering the substance of the brain. Small arteries, ramifying in the pia mater, are given off directly from the larger as well as from the smaller branches, and it is from the finest that the small nutrient arteries descend directly into the cerebral substance. Duret denies the existence of the network of arterial anastomoses usually described in the pia mater, and explains that one cause of error is that the vessels often lie in two layers. He admits, however, that there are some communications between the arteries of the same side and between the two posterior cerebrals.

The general plan of the venous sinuses, has been sufficiently described to be clear, especially with the assistance of Fig. 5. The veins of the brain may be divided into three general sets, those of the convexity, of the base, and of the interior. The first set open into the superior longitudinal sinus, entering it in a direction somewhat opposed to its current. The circulation in these veins is no doubt accelerated by the suction power of the stronger current in the sinus. The veins of the base empty into the sinuses of the neighborhood, and to this system must be reckoned the ophthalmic veins from the orbit.

Venous system.

Duret has shown that a large vein in the Silvian fissure is the only important communication between those of the convexity and of the base. It is into this vein that the ophthalmo-meningea of Hyrtl opens from the orbit, and even, as stated elsewhere, occasionally from the pterygoid plexus. The veins of the interior of the brain and those of the choroid plexuses run into the great vein of Galen, which opens into the straight sinus in the tentorium.

Meningeal veins.

There are several meningeal veins, requiring no detailed description, opening for the most part outside of the skull; the largest corresponds in general with the middle meningeal artery, but a part if not most of its blood passes out through the foramen ovale. One, however, runs along the border of the lesser wing of the sphenoid, becoming converted into a sinus that opens into the sinus cavernosus. It is the spheno-parietal sinus.

Veins of diploë.

The diploë of the bones of the vault is hollowed into venous canals which after middle life are much larger than in the young subject, and which, after the obliteration of the sutures, communicate with one another. We are indebted almost wholly to Breschet for our knowledge of them. He describes a frontal, two parietal, and an occipital one on each side. The frontal one communicates with the superior longitudinal sinus, and through a pretty constant foramen, with the supra-orbital vein, as it passes under the supra-orbital notch. The anterior parietal with the middle meningeal vein, and through a small opening in the great wing of the sphenoid with one of the temporal veins. The posterior parietal is in connection with the lateral sinus, and may pass through the mastoid foramen. The occipital opens both externally and internally, usually at the occipital protuberance. These communications, however, are very uncertain, and when the venous system of the diploë is greatly developed, there is no doubt that many other openings into the sinuses and meningeal veins are to be found. An interesting feature in these veins is that they communicate with those of both the outside and the inside of the skull and thus may serve to equalize the circulation. They are assisted in this by certain other small veins that pass through definite foramina.

Emissaria.

The following may be mentioned as the most important: that through the mastoid foramen, which is very constant, and draws blood directly from the lateral sinus. Those through the posterior condyloid canals, which are less constant but often very large, and also lead from the lateral sinuses; they run into the beginning of the vertebral plexus. There is also usually a vein running through the anterior condyloid foramen. These three foramina are usually larger on the same side as the larger lateral sinus. The parietal foramina are of little consequence. The opening of the superior longitudinal sinus into the nose in childhood accounts for the greater tendency to nose-bleed at that age, and is doubtless a great safeguard, but is usually closed in adult life.

There can be no doubt that the amount of blood in the brain must vary, and the interior of the skull is arranged to allow this variation without prejudice to the safety of the organ. The way in which the brain is maintained in position is one of the most remarkable points of anatomy. A perfectly fresh brain removed from the head will not support its own weight even in fluid. The tentorium serves to remove the weight of the cerebrum from the cerebellum and medulla, and the falx keeps the hemispheres apart, but still it is not probable that these protections alone would be sufficient.

Way in which brain is supported.

For its further protection it rests in part on the cerebro-spinal fluid which gives it a gentle support, and besides this the veins that go from its convexity to the superior sinus may be said to some extent to suspend it.

Much has been written as to whether there are movements of the brain when the skull is in its normal state, and though it is unlikely that they are very marked, there is no reason why there should not be two distinct ones. One depends on the rush of blood in by the arteries, which not only would raise the brain but perhaps slightly expand it, and the other is due to the retardation of the blood in the veins during expiration. The former movement must be synchronous with the pulse, the latter with the respiration. If these motions exist, one purpose of

Uses of cerebro-spinal fluid.

the cerebro-spinal fluid is evident, but also it serves to keep the skull full in both gradual and sudden changes in the amount of blood. If there is an excess of blood the fluid accumulates in the spinal canal, driving by distension of the sheath the blood out of the vertebral plexuses which surround it, and at the same time the orbital veins and other emissaria carry blood to the outside of the head. If the blood in the skull is diminished, the opposite movements take place. It seems also that the fluid can be secreted very rapidly in case there should be any general loss of blood.

CHAPTER XV.

INNERVATION.

THE head, with the exception of a part of the surface which is reached by the spinal nerves, differs from the rest of the body in being supplied with sensation and motion by distinct nerves. It is true that the sensory and motor branches join one another in their course, and thus that in most places the terminal filaments may be called "mixed," but this is not universal, and, owing to the distinct origin of the nerves, we find in the head clearer cases of purely motor or sensory paralysis than elsewhere. The olfactory, optic, and auditory nerves may be dismissed at once as nerves of special sense, and the glosso-pharyngeal has some claim to be similarly classed as the nerve of taste; but though the conveyance of gustatory impressions is its chief function, it probably has others also, and there is little doubt that other nerves assist in tasting. The third, fourth, and sixth pairs distributed to the muscles of the orbit need no additional description, but their union

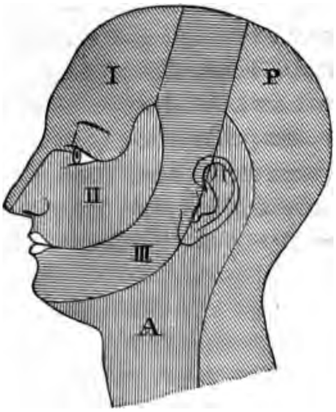

Fig. 10, from Hermann Meyer, showing diagrammatically the nervous supply of the skin. The spaces marked I, II, and III, are supplied respectively by the first, second, and third divisions of the fifth pair. The space marked A is supplied by branches of the anterior divisions of the cervical nerves, and that marked P, by branches from the posterior ones.

with sympathetic fibres, and with some from the fifth pair, may be alluded to. The fifth is the great sensory nerve of the head. Its peripheral distribution is well shown in Fig. 10. As has been mentioned, the distribution of its first division corresponds pretty closely with that of the ophthalmic artery, while that of the second and third has a resemblance to that of the internal maxillary, but is more extensive. The motor part of the third division supplies the muscles of mastication, the anterior belly of the digastric, which from the part it takes in opening the mouth may perhaps be classed among them, and the mylo-hyoid. The first and second divisions of the fifth pair have each a ganglion connected with them, and the third two. These ganglia have a certain general resemblance to those of the sympathetic cords, which, whether it be real or apparent, is of assistance in remembering their connections. Each has a communication with the cerebro-spinal system, which, owing to the nature of the nerves of the head, is necessarily double, consisting of a motor and a sensory root; each is connected with the sympathetic system by branches from the plexuses that follow the arteries, and each sends out branches. Those of the first enter the eyeball and doubtless regulate the action of the internal muscles and the size of the vessels. Those of the otic ganglion apparently have a similar office in the ear, supplying as they do the dilatator tubæ and tensor tympani, though there are other small branches, and the laxator tympani, is supplied by the facial. The submaxillary ganglion presides over the gland and duct. Meckel's ganglion, which is in connection with the second division of the fifth pair, is more complicated. Its branches supply the palate, the walls of the nasal cavities, and the septum. It receives motor fibres from the geniculate ganglion of the facial, which reach it through the Vidian

Ganglia of fifth pair.

nerve, and which are ultimately distributed in the soft palate which is paralyzed in facial paralysis of central origin. It is questioned, however, whether the Vidian nerve does not contain fibres running the other way, namely, from the fifth pair to the geniculate ganglion, and thence along the facial for a short stretch, to leave it at the chorda tympani. This theory, which has a good deal in its favor, would do away with the apparent anomaly

Chorda tympani.

in origin of the chorda, namely, the sudden turning backward of its fibres, and would account for the fact that section of the chorda and paralysis of the facial may occasion no paralysis of the tongue. The facial is also joined at the geniculate ganglion by the tympanic branch of the glosso-pharyngeal. Whether or not the chorda tympani derives its fibres from the facial, it is certain that the power of taste exists along the edges and tip of the tongue, and that in some paralyses of the facial it is lost or weakened, but in other cases it persists, and it has been found both present and absent in paralysis of the fifth. The question of the relation of the chorda to taste is consequently far from settled. The facial nerve presides essentially over the muscles of expression, but it also supplies the posterior belly of the occipito-frontalis, the muscles of the ear, and the posterior belly of the digastric, as well as the muscles of the soft palate. The pneumogastric and spinal accessory have little to do with the head but they have several communications with neighboring nerves. The auricular branch of the vagus supplies in part the external meatus and outer ear and joins a twig of the facial. The pharyngeal branch, which forms a plexus with fibres of the glosso-pharyngeal and sympathetic, is the only other one of importance in this region. The hypoglossal is the motor nerve of the tongue but supplies also the stylo-hyoid, genio-hyoid, and thyro-hyoid. Inside the tongue it has various communications with the gustatory. The sympathetic fibres are very numerous in the head, accompanying the vessels, and joining the other nerves at many points. The influence of the sympathetic on the circulation, the glands, and the organs of special sense, is doubtless very important, though as yet imperfectly understood.

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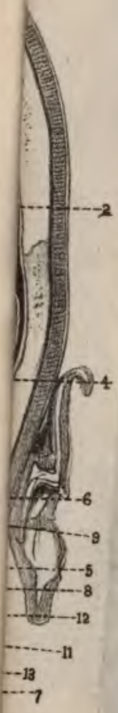
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